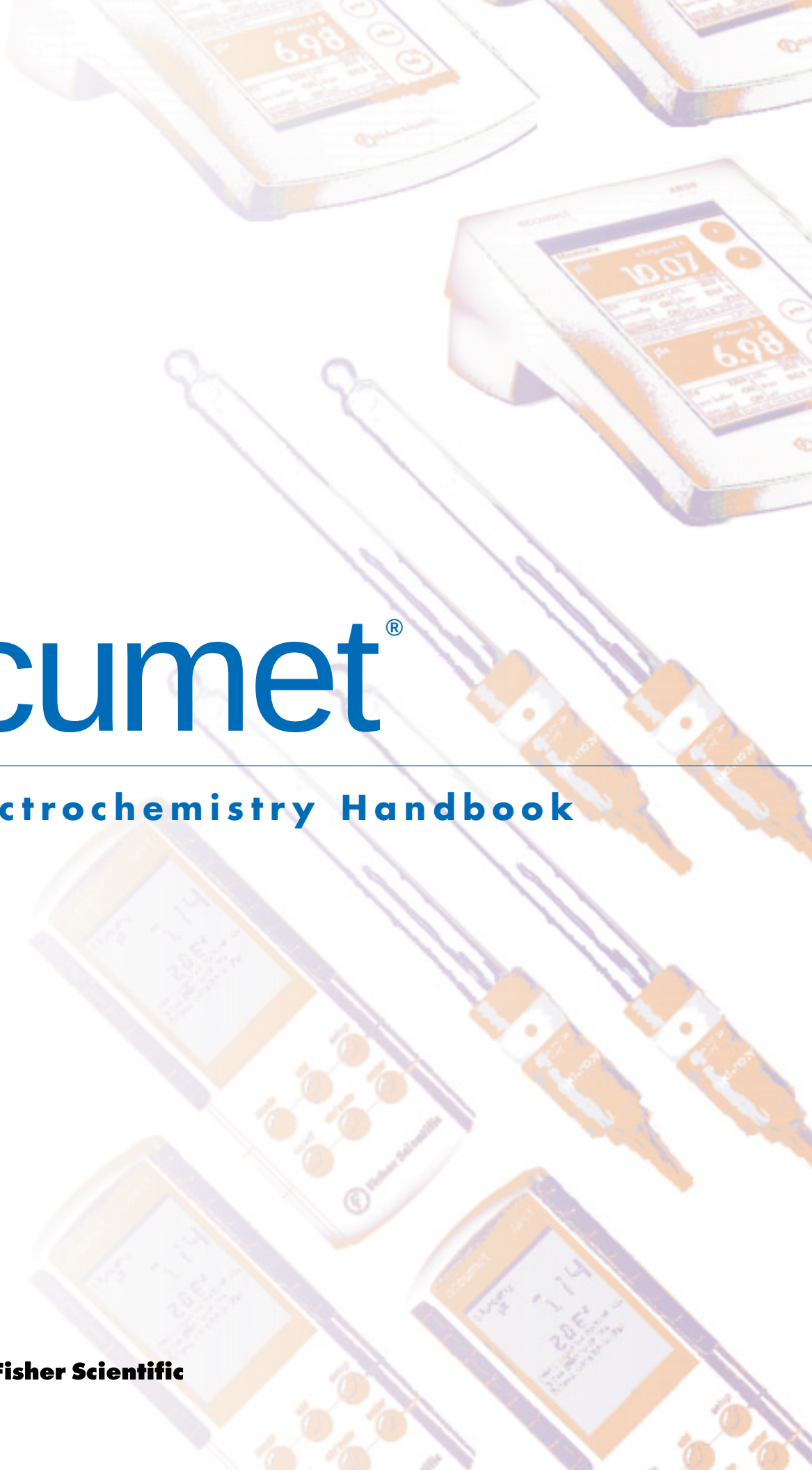


Accumet®

Electrochemistry Handbook

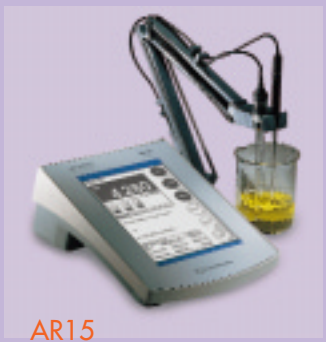
Fisher Scientific

Accumet® Benchtop Meters *pH/mV/Ion/Conductivity*


AR50


AR25


AR20


AR15

Advanced technology makes them simple, accurate, versatile.

Exceptional ease of use: clear language prompts, "HELP" screens and error messages guide you through the measurement process

Large, easy-to-read LCD readouts with reliable, proven touchscreen technology: responds to a light tap, even with gloves or a pencil

Easily customizable screens: let you display only the data you want and need

Two series of meters—Basic and Research Models: to suit your requirements

Fisher's family of Accumet Benchtops has been completely redesigned. Now, they're not only accurate and versatile, but also the easiest to use, most user-friendly pH/mV/ion/conductivity meters you can buy.

From their sleek, compact design to their oversize LCD readouts to their innovative, highly reliable touchscreen technology (Research Models only), Accumet Benchtop Meters put a wealth of information at your fingertips. Just look at what they offer you.

Standardization is ultra simple

Standardizing Accumet Benchtop Meters is so simple a child can do it. Here's all you do:

1. Press "STANDARDIZE" to enter the standardization mode
2. Press "STANDARDIZE" again to perform the standardization

That's all there is to it. In response to your commands, the meter automatically recognizes the buffer, adjusts the buffer value for temperature, waits for a stable reading, enters the data, verifies proper electrode performance, and calibrates the meter.

Throw away your user manual?

We'd certainly never advise you to do it! But Accumet Benchtop Meters are so easy to use, you probably could. Accumet Benchtop Meters feature simple, intuitive operation, on-screen operational prompts, and context-specific "HELP" screens (Accumet Research Models only) designed to guide you through the meter's operation in plain, easily understandable language.

Plus, not only are Accumet Benchtop Meters accurate, versatile, and easy to use, they're backed by a full two-year warranty. Should any Accumet Meter fail to perform to specification under normal use during the first two years, it will be repaired or replaced at no charge.

Easily customize screens and measurement modes to match your requirements

There are two ways to customize the screens and measurement modes on Accumet Benchtop Meters:

Choosing the System Setup Options menu on

Research Model Meters lets you customize the screen display to show exactly the parameters that suit your needs. You can edit the date, screen configuration, time, beeper status, and print configuration.

Customizing within each meter's operational modes (pH/mV/ion/conductivity) lets you select appropriate operating parameters, resolution, buffer sets, and similar settings (different for each operating mode) to match your requirements.

You can also choose either of two procedural levels: Basic Level displays a reduced set of information and restricts user access to a limited list of setup parameters. Advanced Level allows user-configurable output and access to all setup parameters. Using this feature enables scientists to configure the meter in Advanced Level and have a technician perform measurements in Basic Level, limiting the technician's ability to change setup parameters.

Table of Contents

AR10

AB30

AB15

pHree Trial Offer makes it so easy to try one

We're so sure you'll agree that Accumet® Meters offer the best performance, versatility, and value available that we invite you to try one FREE for 30 days with no risk and no obligation. To schedule your Accumet pHree Trial, contact your Fisher Sales Representative.

Choose the meter that makes your job easiest

Two series of Accumet Benchtop Meters are available to match any laboratory's needs:

Accumet Research (AR) Benchtop Meters

- Five single- and multi-function models
- Unparalleled selection of user options lets you customize the meter to your application
- Extra-large, scratch-resistant LCD touch screens (all models except AR10) respond to a light tap, even with gloves or a pencil
- Two procedural levels to fit your needs
- Configurable display shows only data you need
- Plain language prompts and context-specific "HELP" screens guide you through
- Data acquisition via bidirectional communication with computer or printer
- Multiple language option: English, German, French, or Spanish built in
- Rugged ABS plastic housings resist impacts and chemicals

Accumet Basic (AB) Benchtop Meters

- Two models to choose from
- Accurate pH, mV, temperature (AB15) and conductivity measurement (AB30) at an affordable price
- Extra-large LCD shows results clearly
- Five soft-touch membrane switches control all operations
- On-screen plain language prompts and error messages make measurement easier

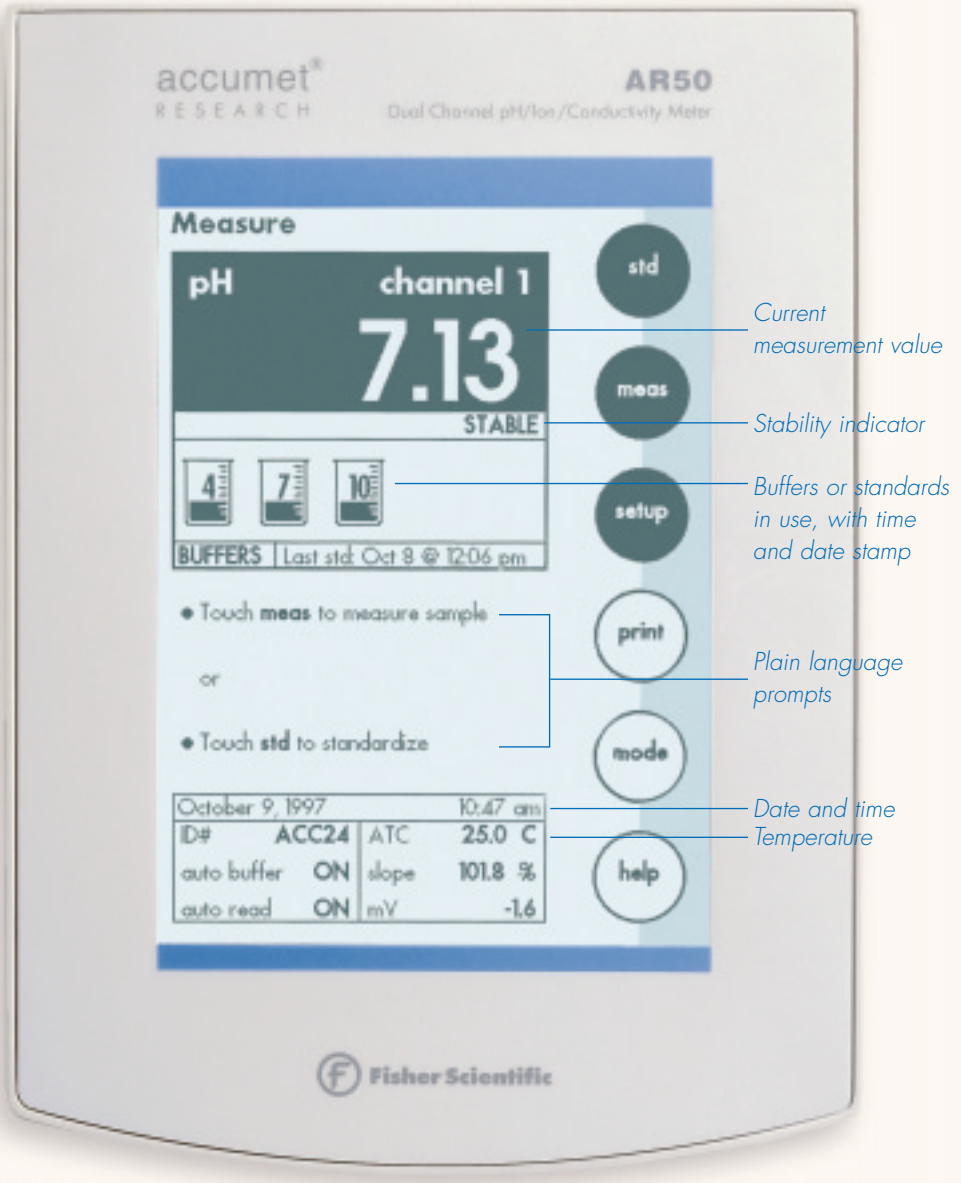
The biggest LCD readouts in their class—plus reliable, user-friendly touchscreen technology

No more squinting at tiny displays. With the biggest LCD readouts in their class, Accumet Benchtop Meters display the information you need precisely and clearly.

Accumet Basic Benchtop Meters feature a soft-touch, membrane switch keypad for operation. It's tough, chemical-resistant, and simple to use.

What's more, Accumet Research Meters (except Model AR10) are the only meters of their type to offer exciting, easy-to-use touchscreen technology—proven reliable in thousands of retail applications worldwide. ("TOUCH" areas of the screen will withstand millions of touches.)

Just touch the scratch-resistant screen with your fingertip to display the information you need, including current measurement value, stability indicator, buffers or standards in use with time/date stamp, plain language prompts, date, time, temperature—and much more!



The Accumet® Research Model **AR50** pH/mV/Ion/Conductivity Meter

Now, it's easy to put a complete electrochemical lab at your fingertips

- **Powerful and versatile—make two different measurements simultaneously**
- **Exceptionally easy to use**
- **Extra-large, scratch- and chemical-resistant LCD readout with dual display**
- **Reliable touchscreen technology responds to a light tap of your finger**
- **Uses standard glass or AccuFet® electrodes with no adapters required**
- **Accepts 2-cell and 4-cell conductivity probes**
- **Built-in replatinizing circuit**
- **Automatically corrects for temperature fluctuations with separate ATC probe in each channel**
- **Data acquisition via bidirectional communication with computer or printer**
- **Multiple language option: English, German, French, or Spanish built in**
- **Select from two procedural levels to match your requirements**

An advanced design and incredible ease of use make the new Accumet AR50 the most versatile, reliable meter of its type you can buy today.

The AR50 offers you the advantages and versatility of having a research-grade pH, mV, ion, and conductivity meter, all in a single instrument, providing you with a dedicated system for a wide range of electrochemical analyses.

Features

- The largest display available; yet compact design saves valuable benchtop space
- User prompts and context-specific "HELP" screens easily guide user through operation
- Extensive setup screens allow you to customize the meter to your needs
- Autocalibrates with up to 5 pH buffers from any of 3 standard sets and 15 different buffers; also accepts custom buffers and manual calibration
- Innovative touchscreen makes it versatile and easy to use
- Dual channel meter allows you to measure two parameters at once and view results from both channels on screen simultaneously
- Reads pH to 0.001, mV to 0.1, plus conductivity, resistivity, salinity, and TDS
- Reads ISE in ppm, %, mg/mL, and mole/L
- Direct and indirect ISE measurements, including known addition and subtraction, and analate addition and subtraction methods
- Extensive GLP capabilities with customizable printer or computer output and 250 reading datalog capability
- Print setup allows you to print exactly what you want, exactly when you want, not just a screen dump
- Time can be displayed in 12- or 24-hour formats and date in U.S. or international format
- Accepts standard BNC glass electrodes as well as an AccuFet electrode directly—no need for an adapter
- Accepts two-cell and four-cell conductivity probes
- Built-in replatinizing circuit
- Automatically corrects for temperature fluctuations with separate ATC (Automatic Temperature Compensation) probe in each channel

Simple customization lets you fit the system to your needs

You can easily customize the AR50 Meter screen to set measurement mode operating parameters, display only the information you need, or match your operating needs. There are two ways to do this:

- Choosing the "SYSTEM SETUP OPTIONS" menu lets you customize and simplify the screen displays to show exactly the parameters that suit your needs. You can edit the date, screen configuration, time, beeper status, and print configuration.
- Customizing within each of the AR50's operating modes (pH/mV/ion/conductivity) lets you select and set the operating parameters you wish to display, including resolution, buffer sets, and similar settings (different for each operating mode) to match your requirements.

You can also choose either of two procedural levels: Basic Level displays a reduced set of information and limits user access to the full list of setup parameters; Advanced Level allows user-configurable output and access to all setup parameters. Using this feature, scientists can configure the meter in Advanced Level and have a technician perform measurements in Basic Level, limiting the technician's ability to change setup parameters.

Specifications and Ordering Information	
Displays	**640 x 480 LCD**
Screen size	$4^1/_2$W x 6"H
Measurement display height	$^3/_4$"H
Temp./etc. display height	$^1/_4$"H
Memory	**250 data points**
Internal diagnostics	Yes
Programmable data output	Output on stable, time, manual
Print interval	1 to 9,999 sec.
Programmable alarm	Yes
pH mode	
Range	-2.000 to +20.000
Resolution	0.1/0.01/0.001
Relative accuracy	±0.002
Auto/manual buffer recognition	Yes
Calibration points	5
mV mode	
Range	±1800.0
Resolution	0.1
Accuracy	±0.1
Ion mode	
Range	1×10^{-6} to 9.99×10^{10}
Resolution	4 significant figures
Relative accuracy	±0.17n%
Calibration points	5
Incremental methods	KA, KS, AA, AS
Conductivity mode	
Cell constants	0.1/1.0/10
Ranges:	
Conductivity	0 to 3×10^5µS/cm
Resistivity	30megohm-cm to 100megohm-cm
Salinity	2 to 42ppt
Accuracy	±0.5%
Temperature mode	
Range	-5.0° to +105°C
Resolution	0.1°C
Accuracy	±0.2°C
Inputs/outputs	
	2 BNC, 2 Pin, 2 ATC, 2-pin conductivity, bidirectional RS-232, 2 DIN (for FET and 4-cell conductivity)
Meter size	
	$6^1/_2$W x $9^1/_4$L x $3^1/_2$"H; 165 x 235 x 89mm
Meter weight	
	2.34 lb. (1.1kg)

Description	Catalog No.
AR50 Meter Kit: includes meter, Ag/AgCl combination pH electrode, ATC probe, electrode support arm and bracket, user manual, and power supply.	**13-636-AR50**
AR50B Meter Kit: includes meter, AccuTu**pH+**® rugged bulb calomel combination pH electrode for Tris-buffer applications, ATC probe, electrode support arm and bracket, user manual, and power supply.	**13-636-AR50B**
AR50A Meter only: includes meter, electrode support arm and bracket, user manual, and power supply.	**13-636-AR50A**

The Accumet® Research Model **AR25** pH/mV/Ion Meter

Dual channels let you measure and view two parameters at once

- **Powerful—measure pH and ion simultaneously**
- **Intuitive user interface makes it exceptionally easy to use**
- **Extra-large, scratch- and chemical-resistant LCD readout with dual display**
- **Reliable touchscreen technology responds to a light tap of your finger**
- **Automatically corrects for temperature fluctuations with separate ATC probe in each channel**
- **Data acquisition via bidirectional communication with computer or printer**
- **Multiple language option: English, German, French, and Spanish built in**
- **Uses standard glass or an AccuFet electrode with no adapter required**

The Accumet AR25 Meter is fully equipped for the most demanding pH and ion measurements, yet is so simple to use almost anyone can do it. It offers Accumet accuracy and reliability plus innovative, dependable touchscreen technology, proven in thousands of applications worldwide. Its user-friendly design gives you an unparalleled range of user-determined setup, screen display, data storage, and printing options. Its dual-channel design is like having two meters in one. You can display one channel at a time, or toggle to split screen for simultaneous viewing. For the lab that needs the versatility of a research grade pH meter and an ion meter, it's an easy choice.

Features

- The largest display available; yet compact design saves valuable bench space
- User prompts and context-specific "HELP" screens easily guide user through operation
- Extensive setup screens allow you to customize the meter to your needs
- Autocalibrates with up to 5 pH buffers from any of 3 standard sets and 15 different buffers; also accepts custom buffers and manual calibration
- Innovative touchscreen makes it versatile and easy to use
- Dual channel meter allows you to measure two parameters at once, and view results from both channels on screen simultaneously
- Reads pH to 0.001, mV to 0.1
- Reads ISE in ppm, %, mg/mL, and mole/L
- Direct and indirect ISE measurements, including known addition and subtraction, and analate addition and subtraction methods
- Extensive GLP capabilities with customizable printer or computer output and 250 reading datalog capability
- Print setup allows you to print exactly what you want, when you want it, not just a screen dump
- Time can be displayed in 12- or 24-hour format, and date can be displayed in U.S. or international format
- Accepts standard glass electrodes or an AccuFet® electrode directly—no need for an adapter
- Automatically corrects for temperature fluctuations with ATC probe

Specifications and Ordering Information	
Displays	**640 x 480 LCD**
Screen size	4 1/2W x 6"H
Measurement display height	3/4"H
Temp./etc. display height	1/4"H
Menu options	Extensive
Memory	**250 data points**
Internal diagnostics	Yes
Programmable data output	Output on stable, time, manual
Print interval	1 to 9,999 sec.
Programmable alarm	Yes
pH mode	
Range	-2.000 to +20.000
Resolution	0.1/0.01/0.001
Relative accuracy	±0.002
Auto/manual buffer recognition	Yes
Calibration points	5
mV mode	
Range	±1800.0
Resolution	0.1
Accuracy	±0.1
Ion mode	
Range	1 x 10^{-6} to 9.99 x 10^{10}
Resolution	4 significant figures
Relative accuracy	±0.17n%
Calibration points	5
Incremental methods	KA, KS, AA, AS
Temperature mode	
Range	-5.0° to +105.0°C
Resolution	0.1°C
Accuracy	±0.2°C
Inputs/outputs	
	2 BNC, 2 Pin, 2 ATC, bidirectional RS-232, DIN (for FET)
Meter size	
	6 1/2W x 9 1/4L x 3 1/2"H 165 x 235 x 89mm
Meter weight	
	2.34 lb. (1.1kg)

Description	Catalog No.
AR25 Meter Kit:	**13-636-AR25**
includes meter, Ag/AgCl combination pH electrode, ATC probe, electrode support arm and bracket, user manual, and power supply.	
AR25B Meter Kit:	**13-636-AR25B**
includes meter, AccuTu**pH+**® rugged bulb Accu•**pH**ast® combination pH electrode for Tris-buffer applications, ATC probe, electrode support arm and bracket, user manual and and power supply.	
AR25A Meter only:	**13-636-AR25A**
includes meter, electrode support arm and bracket, user manual, and power supply.	

The Accumet® Research Model **AR20** pH/mV/Conductivity Meter

Same accuracy as our top model—pH, mV, and conductivity readout

- **Large, easy-to-use LCD touchscreen displays information clearly**
- **Exceptional user interface with plain language prompts make it a breeze to use**
- **Select from two procedural levels to suit your needs**
- **Accepts 2-cell and 4-cell conductivity probes**
- **Built-in replatinizing circuit**
- **Automatically corrects for temperature fluctuations with ATC probe**
- **Data acquisition via bidirectional communication with computer or printer**
- **Multiple language option: English, German, French, or Spanish built in**

The newly-designed Accumet AR20's powerful conductivity and pH modes provide the same performance and ease of use as our top-of-the-line AR50. You also get the convenience and benefits of our extra-large touchscreen technology, with an unequaled range of user-determined setup, screen display, data storage, and printing options.

Features

- The largest display available; yet compact design saves valuable bench space
- On-screen prompts in plain language and context-specific "HELP" screens easily guide user through operation
- Autocalibrates with up to 5 pH buffers from any of 3 standard sets and 15 different buffers; also accepts custom buffers, and manual calibration
- Innovative touchscreen makes it versatile and easy to use
- Reads pH to 0.001, mV to 0.1, plus conductivity, resistivity, salinity, and TDS
- Extensive GLP capabilities with customizable printer or computer output and 250 reading datalog capability
- Autoranging capability
- Print setup allows you to print exactly what you want, when you want, not just a screen dump
- Time can be displayed in 12- or 24-hour format; date can be displayed in U.S. or international formats
- Accepts standard glass electrode or an AccuFet® electrode directly—no need for an adapter

Specifications and Ordering Information	
Displays	**640 x 480 LCD**
Screen size	4 1/2W x 6"H
Measurement display height	3/4"H
Temp./etc. display height	1/4"H
Memory	**250 data points**
Internal diagnostics	Yes
Programmable data output	Output on stable, time, manual
Print interval	1 to 9,999 sec.
Programmable alarm	Yes
pH mode	
Range	-2.000 to +20.000
Resolution	0.1/0.01/0.001
Relative accuracy	±0.002
Auto/manual buffer recognition	Yes
Calibration points	5
mV mode	
Range	±1800.0
Resolution	0.1
Accuracy	±0.1
Conductivity mode	
Cell constants	0.1/1.0/10
Ranges:	
Conductivity	0 to 3 x 10^5µS/cm
Resistivity	30megohm-cm to 100megohm-cm
Salinity	2 to 42ppt
Accuracy	0.5%
Temperature mode	
Range	-5.0° to +105.0°C
Resolution	0.1°C
Accuracy	±0.2°C
Inputs/outputs	
	BNC, Pin, ATC, 2-pin conductivity, bidirectional RS-232, 2 DIN (for FET and 4-cell conductivity)
Meter size	
	6 1/2W x 9 1/4L x 3 1/2"H 165 x 235 x 89mm
Meter weight	
	2.34 lb. (1.1kg)

Description	Catalog No.
AR20 Meter Kit:	**13-636-AR20**
includes meter, Ag/AgCl combination pH electrode, ATC probe, electrode support arm and bracket, user manual, and power supply.	
AR20B Meter Kit:	**13-636-AR20B**
includes meter, AccuTu**pH+**® rugged bulb Accu•**pH**ast® combination pH electrode for Tris-buffer applications, ATC probe, electrode support arm and bracket, user manual and power supply.	
AR20A Meter only:	**13-636-AR20A**
includes meter, electrode support arm and bracket, user manual, and power supply.	

The Accumet® Research Model **AR15** pH/mV/°C Meter

An easy-to-use, dedicated pH/mV meter for research-grade measurements

- **Large, scratch- and chemical-resistant LCD readout with reliable touchscreen technology for ease of operation**
- **Intuitive operation with on-screen, plain language prompts and "HELP" screens that guide you through the measurement process**
- **Data acquisition via bidirectional communication with computer or printer**
- **Multiple language option: English, German, French, or Spanish built in**

The Accumet AR15 Meter measures pH and mV with all the power and ease of use of the top-of-the-line AR50. It automatically recognizes USA, Euro, NIST, or custom buffers. Its remarkable user interface makes it exceptionally easy to use, and a full complement of plain-language prompts and "HELP" screens guide you through the measurement process.

Features

- Innovative, reliable touchscreen technology makes it versatile and easy to use
- User prompts and context-specific "HELP" screens easily guide user through operation
- Extensive setup screen allows you to customize the meter to your needs
- Autocalibrates up to 5 pH buffers from any of 3 standard sets and 15 different buffers; also accepts custom buffers and manual calibration
- Reads pH to 0.001 and mV to 0.1
- Extensive GLP capabilities with customizable printer or computer output and 250 reading datalog capability
- Print setup allows you to print exactly what you want, when you want it, not just a screen dump
- Time can be displayed in 12- or 24-hour format; date can be displayed in U.S. or international format
- Accepts standard glass electrode or AccuFet® electrode directly—no need for an adapter
- Automatically corrects for temperature fluctuations with ATC probe

Specifications and Ordering Information	
Displays	**640 x 480 LCD**
Screen size	4 1/2W x 6"H
Measurement display height	3/4"H
Temp./etc. display height	1/4"H
Memory	**250 data points**
Internal diagnostics	Yes
Programmable data output	Output on stable, time, manual
Print interval	1 to 9,999 sec.
Programmable alarm	Yes
pH mode	
Range	-2.000 to +20.000
Resolution	0.1/0.01/0.001
Relative accuracy	±0.002
Auto/manual buffer recognition	Yes
Calibration points	5
mV mode	
Range	±1800.0
Resolution	0.1
Accuracy	±0.1
Temperature mode	
Range	-5.0° to +105.0°C
Resolution	0.1°C
Accuracy	±0.2°C
Inputs/outputs	
	BNC, Pin, ATC, bidirectional RS-232, DIN (for FET)
Meter size	
	6 1/2W x 9 1/4L x 3 1/2"H 165 x 235 x 89mm
Meter weight	
	2.34 lb. (1.1kg)

Description	Catalog No.
AR15 Meter Kit:	**13-636-AR15**
includes meter, Ag/AgCl combination pH electrode, ATC probe, electrode support arm and bracket, user manual, and power supply.	
AR15B Meter Kit:	**13-636-AR15B**
includes meter, AccuTu**pH**® rugged bulb double-junction combination pH electrode for Tris-buffer applications, ATC probe, electrode support arm and bracket, user manual, and power supply.	
AR15A Meter only:	**13-636-AR15A**
includes meter, electrode support arm and bracket, user manual, and power supply.	

The Accumet® Research Model **AR10** pH/mV/°C Meter

Performance, reliability, and economy in an easy-to-use digital pH meter

- **Simple design and operation plus research-grade performance**
- **Sleek, modern design**
- **Compact—small footprint saves valuable bench space**

The Accumet AR10 Meter gives you reliable, research-grade pH and mV measuring capabilities in a package that is ideal for classrooms and industrial labs. A big, four-digit LCD makes reading measurements easy, and four-knob rotary control makes it simple to use.

Features

- Reads pH to 0.01 and mV to 1
- Solid-state circuitry with digital display and rotary knobs
- Ideal for educational use
- Automatically corrects for temperature fluctuations with ATC probe

Replacement Parts and Accessories for Accumet AR Series Benchtop Meters

Description	Catalog No.
For Accumet AR Series Benchtop Meters	
pH combination electrode, Ag/AgCl, single junction, glass body, BNC connector; replacement for AR10, AR15, AR20, AR25, AR50	**13-620-285**
AccuFet® solid-state pH/ATC combination electrode, Ag/AgCl	**13-620-755**
ATC probe, stainless steel; for all AR Series meters	**13-620-19**
Electrode support arm for all AR Series meters	**13-637-671**
Electrode arm bracket for all AR Series meters	**13-637-671A**
Power Supply—115V, 60Hz, US plug	**13-636-100**
For Accumet AR50, AR25, AR20, AR15 Benchtop Meters	
Printer, including printer, cable, ribbon, paper. For 115V	**13-637-670**
Printer Paper	**13-637-669**
Printer Replacement Ribbon	**13-637-668**
Printer Cable	**13-637-667**
Computer Cable for AR Series (9-pin to 9-pin)	**13-637-680**

Conductivity Cells for AB30, AR20, AR50

	2-Cell Conductivity Cell		4-Cell Conductivity Cell	
	Glass Body	Epoxy Body	Glass Body	Epoxy Body
Accumet Immersion Type Conductivity Electrodes				
Cell constant 0.1cm^{-1}	**13-620-156**	**13-620-161**	---	---
Cell constant 1.0cm^{-1}	**13-620-155**	**13-620-160**	**13-620-163**	**13-620-165**
Cell constant 10.0cm^{-1}	**13-620-157**	**13-620-162**	**13-620-164**	**13-620-166**

Specifications and Ordering Information

Displays	**4-digit LCD**
Screen size	2¼W x 1″H
Measurement display height	¾″H
Keypad controls	4-knob rotary
Programmable data output	Recorder (±1800mV)
pH mode	
Range	-1.99 to +19.99
Resolution	0.01
Relative accuracy	±0.02
Manual buffer recognition	Yes
Calibration points	2
mV mode	
Range	±1800.0
Resolution	1
Accuracy	±1
Temperature mode	
Range	0°C to 100.0°C
Resolution	0.1°C
Accuracy	±0.5°C
Inputs/outputs	
	BNC, Pin, ATC, Recorder, DIN (for FET)
Meter size	
	6½W x 9¼L x 3½″H 165 x 235 x 89mm
Meter weight	
	2.34 lb. (1kg)

Description	Catalog No.
AR10 Meter Kit:	**13-636-AR10**
includes meter, Ag/AgCl combination pH electrode, ATC probe, electrode support arm and bracket, user manual, and power supply.	
AR10A Meter only:	**13-636-AR10A**
includes meter, electrode support arm and bracket, user manual, and power supply.	

The Accumet® Basic Model **AB30** Conductivity/°C Meter

An accurate, affordable, easy-to-operate dedicated conductivity meter

- **Easy-to-read custom LCD—displays information clearly**
- **Shows measurements in conductivity, resistivity, or total dissolved solids units**
- **Clear user interface with plain language prompts make it a breeze to use**

The Accumet Basic AB30 Conductivity Meter features a large digital display that shows stability indicators as well as user prompts and error messages in plain language, making it exceptionally easy to use. The AB30 Meter measures conductivity, resistivity, and total dissolved solids, and all measurements are corrected for temperature fluctuations with the ATC probe (supplied with kit).

Features

- Reads conductivity, resistivity, and total dissolved solids to 4 significant figures
- Large display shows measurement and temperature at all times
- Easy-to-use operation with user prompts on screen, stability indicators, and error messages
- Automatically corrects for temperature fluctuations with ATC probe
- Accepts two-cell and four-cell conductivity probes
- Small, compact size conserves valuable bench space

Specifications and Ordering Information

Display	Custom LCD
Screen size	3W x 4 1/4"H
Measurement display height	3/4"H
Temp./etc. display height	5/16"H
Keypad controls	5-key soft touch membrane
Conductivity mode	
Cell constants	0.1, 1.0, 10
Ranges:	
Conductivity	0 to 3 x 10^5µS/cm
Resistivity	30megohm-cm to 100megohm-cm
TDS	0 to 1.8 x 10^5ppm
Accuracy	±0.5%
Temperature mode	
Range	-5.0° to +105.0°C
Resolution	0.1°C
Accuracy	±0.5°C
Inputs	
	2-cell (2 pins) conductivity, 4-cell (DIN) conductivity, ATC probe
Meter size	
	5 1/2W x 7 1/2L x 3 1/4"H 140 x 191 x 83mm
Meter weight	
	1.86 lb. (0.8kg)

Description	Catalog No.
AB30 Meter Kit:	**13-636-AB30**
includes meter, ATC probe, electrode support arm and bracket, user manual, and power supply.	
AB30A Meter only:	**13-636-AB30A**
includes meter, electrode support arm and bracket, user manual, and power supply.	

Replacement Parts and Accessories for Accumet AB Series Benchtop Meters

Description	Catalog No.
pH/ATC electrode, Ag/AgCl, single junction, polypropylene, BNC connector; replacement for AB15	**13-620-530**
pH/ATC electrode, calomel, single junction, polypropylene, BNC connector; replacement for BioBasic AB15B	**13-620-531**
AccuFet® solid-state pH/ATC combination electrode, Ag/AgCl	**13-620-755**
ATC probe, stainless steel; for all AB Series meters	**13-620-19**
Electrode support arm for all AB Series meters	**13-637-671**
Electrode arm bracket for all AB Series meters	**13-637-671A**
Power Supply—115V, 60Hz, US plug	**13-636-100**

Conductivity Cells for AB30

	2-Cell Conductivity Cell		4-Cell Conductivity Cell	
	Glass Body	Epoxy Body	Glass Body	Epoxy Body
Accumet Immersion Type Conductivity Electrodes				
Cell constant 0.1cm^{-1}	**13-620-156**	**13-620-161**	---	---
Cell constant 1.0cm^{-1}	**13-620-155**	**13-620-160**	**13-620-163**	**13-620-165**
Cell constant 10.0cm^{-1}	**13-620-157**	**13-620-162**	**13-620-164**	**13-620-166**

The Accumet® Basic Model **AB15** pH/mV/°C Meter

Intuitive, simple operation, and high accuracy in a compact, affordable meter

- **Same quality as our top-of-the-line AR50 Research Meter**
- **Largest LCD readout in its class**
- **Accepts standard glass or AccuFet® electrode directly with no adapter needed**

Easy operation, accuracy, and affordability set the Accumet Basic AB15 Meter apart from the competition.

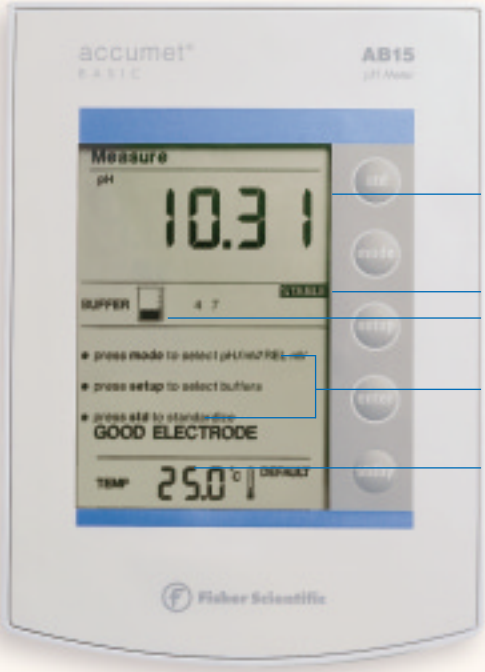
A large custom LCD makes the AB15 Meter easy to read, while plain language prompts and error messages guide the user through measurements. A rugged, chemical-resistant five-button soft touch membrane keypad controls all operations. The AB15 Meter automatically corrects for temperature fluctuations using an ATC probe.

The AB15 Meter Kit includes Ag/AgCl combination pH/ATC electrode. Life science and other researchers using Tris buffers can choose the AB15B BioBasic Meter Kit, complete with calomel electrode with built-in ATC probe.

For laboratories needing a basic, accurate, easy-to-use pH/mV meter, the AB15 Meter is the perfect choice.

Features

- Measures pH, mV, and relative mV to 0.01 pH and 1mV
- Large display shows pH or mV and temperature at all times
- Autocalibrates with up to 5 pH buffers from any 3 standard sets and 15 different buffers
- Easy-to-use operation with user prompts, stability indicators, and error messages on screen
- Accepts a standard glass electrode or AccuFet® electrode directly—no adapter needed
- Automatically corrects for temperature fluctuations with ATC probe
- Standardization curves for standard glass and the AccuFet electrode stored in memory—switch electrodes quickly with no need to restandardize
- Small, compact size conserves valuable bench space



Current measurement value

Stability indicator

Buffer standardization (pH mode)

Plain language prompts

Temperature indicator

Specifications and Ordering Information	
Display	**Custom LCD**
Screen size	3W x 4¼"H
Measurement display height	¾"H
Temp./etc. display height	5/16"H
Keypad controls	5-key soft touch membrane
Internal diagnostics	
	Yes
pH mode	
Range	-1.99 to +19.99
Resolution	0.1/0.01
Relative accuracy	±0.01
Automatic buffer recognition	Yes
Calibration points	5
mV mode	
Range	±1800.0
Resolution	1
Accuracy	±0.2
Temperature mode	
Range	-5.0°C to +105.0°C
Resolution	0.1°C
Accuracy	±0.2°C
Inputs	
	BNC, Pin, ATC, DIN (for FET)
Meter size	
	5½W x 7½L x 3¼"H 140 x 191 x 83mm
Meter weight	
	1.86 lb. (0.8kg)

Description	Catalog No.
AB15 Meter Kit:	**13-636-AB15**
includes meter, Ag/AgCl combination pH/ATC electrode, electrode support arm and bracket, user manual, and power supply.	
AB15B BioBasic Meter Kit:	**13-636-AB15B**
includes meter, calomel combination pH/ATC electrode for Tris-buffer applications, electrode support arm and bracket, user manual, and power supply.	
AB15A Meter only:	**13-636-AB15A**
includes meter, electrode support arm and bracket, user manual, and power supply.	

Easy-to-read liquid crystal display is the largest in its class

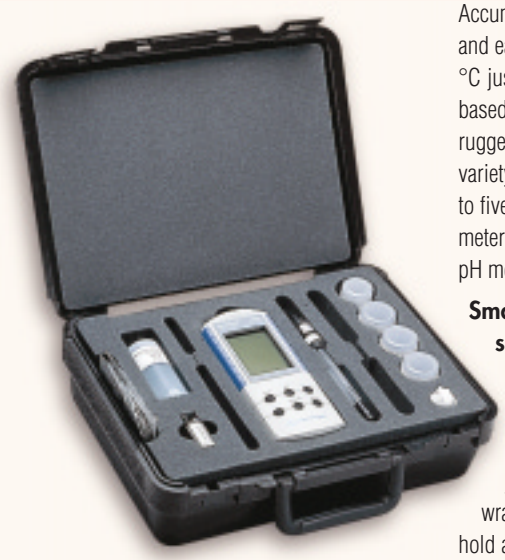
The AB15 Meter's large, liquid crystal display (LCD) makes it exceptionally easy to use and read. Operation is controlled by only five soft touch membrane keys.


AP61


AP62


AP63

Accurate, portable, easy to use. Precise measurements any time, anywhere



- **Three models to match your remote testing and sampling requirements**
- **Large, easy-to-read LCD readouts**
- **Same simple, intuitive operation as Accumet Basic Series Benchtop Meters**
- **Six-button, soft touch keypad**
- **Ergonomic design makes them comfortable to hold**
- **Waterproof to IP67 standards—in fact, they float!**

Accumet Portable (AP) pH meters are so compact and easy to use, you can test for pH, mV, Ion, and °C just about anywhere. Their microprocessor-based accuracy and precision, coupled with their rugged, waterproof design make them ideal for a variety of remote testing applications. Offering up to five calibration points, Accumet Portable pH meters provide the ultimate in portable pH measurement.

Small enough to fit in your shirt pocket

Compact, rugged Accumet Portable pH meters can be used almost anywhere, from the R&D lab to the factory floor to the job site. Their trim shape and rubberized, wraparound grips make them comfortable to hold and operate with just one hand. Choose the AP61 for pH-only measurements, the AP62 for pH/mV, or the AP63 for pH, mV, or ion applications. All models also measure temperature in °C.

Easy to use, comfortable to hold

A user interface similar to that used in Accumet Basic Benchtop meters makes Accumet Portable pH meters exceptionally easy to operate. Six sealed, soft-touch entry keys let you scroll easily through menu options. pH mode features selectable resolution to 0.01, automatic temperature compensation, automatic recognition of 5 buffers, and five-point calibration. (The AP63 also features automatic recognition of 5 standards and five-point calibration in ion mode.) Plain language on-screen prompts and error messages make getting good results easy, even for inexperienced operators.

Rugged and waterproof

A tough, ABS plastic housing lets Accumet Portable pH meters take hard use in stride. In fact, to help you handle even the most difficult remote measurement applications, they're waterproof to IP67 standards and will even float if dropped in water. Accumet Portable pH meters operate from a 9V battery or with an optional AC adapter.

Backed by a full two-year warranty

Not only are Accumet Portable meters accurate, versatile, and easy to use, they're backed by a full two-year warranty. Should any Accumet meter fail to perform to specification under normal use during the first two years, it will be repaired or replaced at no charge.

Replacement Parts and Accessories for Accumet AP60 Series Portable Meters

Description	Catalog No.
Power Supply, 115V, 60Hz, US plug	**13-636-100**
pH/ATC electrode, Ag/AgCl, single junction, polypropylene, refillable	**13-620-AP50**
pH/ATC electrode, calomel, single junction, polypropylene, refillable	**13-620-AP51**
pH/ATC electrode, double junction, epoxy body, gelled Ag/AgCl electrolyte	**13-620-AP52**
ATC probe, stainless steel for all AP60 Series meters	**13-620-AP53**
Accumet Portable Lab (Carrying Case)	**13-636-AP69**

Note: Accumet AP Series Portable Meters are only waterproof to IP67 standards when used with AP Series electrodes above, and with AC adapter cap in place. Meters are not waterproof when used with AC adapter.

pHree Trial Offer makes it so easy to try one

We're so sure you'll agree that Accumet® Portable meters offer the best performance, versatility, and value available that we invite you to try one FREE for 30 days with no risk and no obligation. To schedule your Accumet pHree Trial, contact your Fisher Sales Representative.

Specifications and Ordering Information

Accumet Portable AP61 pH/°C Meter

Displays	Custom LCD
Screen size	$1^{15}/_{16}$W x $2^{1}/_{2}$"H
Measurement characters	$^{7}/_{16}$"H
Other data characters	$^{1}/_{4}$"H
Keypad controls	**6-key membrane**
Internal diagnostics	Self-test, error message
Waterproofing	IP67†
pH mode	
Range	-1.99 to +19.99
Resolution	0.1/0.01
Relative accuracy	±0.01
Auto buffer recognition	2, 4, 7, 10, 12
Calibration points	1 to 5
Temperature mode	
Range	-5.0° to +100.0°C
Resolution	0.1°C
Relative accuracy	±0.3°C
Compensation	Automatic
Inputs	
	BNC, ATC
Electrical requirements	
	9V battery or optional AC adapter
Battery life	
	>200 hr.

Description	Catalog No.
AP61 Meter Kit‡	**13-636-AP61**
AP61A Meter only‡	**13-636-AP61A**

Specifications and Ordering Information

Accumet Portable AP62 pH/mV/°C Meter

Same specifications as Model AP61 plus:

mV mode	
Range	0 to ±999
Resolution	1.0
Relative accuracy	±0.1

Description	Catalog No.
AP62 Meter Kit‡	**13-636-AP62**
AP62A Meter only‡	**13-636-AP62A**

Specifications and Ordering Information

Accumet Portable AP63 pH/mV/Ion/°C Meter

Same specifications as Model AP62 plus:

Ion mode	
Range	1×10^{-3} to 9.99×10^{4}
Relative accuracy	±0.17n%
Calibration points	5
Resolution	2 or 3 significant digits

Description	Catalog No.
AP63 Meter Kit‡	**13-636-AP63**
AP63A Meter only‡	**13-636-AP63A**

†**IP67 Standard:** Meter can be submerged for 30 minutes to a depth of 1m and still remain operational.

‡**Meter only versions** include meter, 9V battery, and user manual.

Meter Kits include meter, 9V battery, Accumet liquid-filled polymer body pH/ATC Ag/AgCl electrode, user manual and hard carrying case with 4 empty buffer bottles and 4 single-use pH buffer pouches.

pH Theory and Measurement

pH Working Theory

Since its 1909 introduction, pH measurement has become increasingly important in laboratories and industries. Close pH control is of primary importance in life processes, in sanitary engineering and electroplating, and in textile, pharmaceutical, and food industries. Modern meters and new electrodes have made pH measurement as simple and convenient as temperature measurement.

In general, pH is a measure of the degree of acidity or alkalinity of a substance. It's related to the effective or active acid concentration of a solution by this equation:

$$pH = -\log \alpha H^+$$

with aH^+ representing the activity of the hydrogen ions in the solution. Neglecting activity effects, the equation above reduces to:

$$pH = -\log [H^+]$$

with $[H^+]$ representing the concentration of hydrogen ions in solution. pH is sometimes referred to as the power of the hydrogen ion in solution. The pH of the strong acid 0.01 molar HCl is equal to 2, since its hydrogen ion concentration is 10^{-2} molar:

$$pH = -\log [10^{-2}]$$
$$pH = 2$$

The pH scale in water is usually considered to range from 0 to 14, or from an active acid concentration of $[1 \times 10^0]$ to $[1 \times 10^{-14}]$ (1.0M to 0.00000000000001M). Some current pH meters can measure to -2pH (10^2M) and to +20pH (10^{-20}M).

The pH scale is based on the dissociation constant of water. In pure water, a very small number of molecules react with one another to form hydronium ions (H_3O^+)—which account for acidic properties—and hydroxide ions (OH^-)—which account for the basic properties of an aqueous solution.

$$2H_2O \Leftrightarrow H_3O^+ + OH^-$$

or, for simplicity:

$$H_2O \Leftrightarrow H^+ + OH^-$$

At 25°C, pure water dissociates until the acid $[H^+]$ and base $[OH^-]$ concentrations are equal, at 1×10^{-7} molar. The product of both concentrations is the dissociation constant K_w:

$$K_w = [H^+][OH^-]$$
$$K_w = [1 \times 10^{-7}][1 \times 10^{-7}]$$
$$K_w = [1 \times 10^{-14}]$$

Because its hydrogen ion concentration $[H^+]$ equals 1×10^{-7} molar, the pH of pure water at 25°C is 7. This is referred to as the neutrality point.

In aqueous solutions, at 25°C, the product of $[H^+]$ and $[OH^-]$ must remain constant at 1×10^{-14}; an increase in either acid or base concentration always results in a decrease in the other. Hence, a solution of the strong base 0.01M NaOH will have a hydrogen ion concentration of:

$$H^+ = \frac{K_W}{[OH^-]} = \frac{10^{-14}}{10^{-2}} = 10^{-12}$$

Thus:

$$pH = -\log [10^{-12}]$$
$$pH = 12$$

pH Measurement Systems

Although pH can be determined using colorimetric indicators or indicator papers, the preferred method is potentiometric measurement, using a pH meter and electrode system. This method is based on the fact that certain electrodes, immersed in a solution, produce a voltage that is related to the pH value of the solution in a very precise way. This voltage can be predicted by the Nernst equation. Simplified, the equation is:

$$E_{meas} = E^0 - \frac{2.3}{nF} RT\,(pH)$$

where E_{meas} is the measured voltage; E^0 is the total of all constant voltages in the measurement system; R is the Gas Law constant; T is the temperature in °K; n is the charge of the ion; and F is Faraday's constant.

The pH Meter

The pH Meter is a specialized voltmeter. It can accurately measure small voltage changes at extremely high resistances exhibited by electrodes. And it can adjust to the pH and voltage characteristics of the electrode system. Most modern pH meters incorporate manual or automatic temperature compensation to correct for variations in pH value of a given solution with sample temperature, as expressed in the Nernst equation. To compensate for electrode output variations, most meters are equipped with a slope or efficiency control to adjust the meter to match electrode voltage exactly. Microprocessor-based meters are programmed to solve the Nernst equation, taking into account electrode voltage, efficiency and temperature. Most provide automatic buffer recognition and standardization, as well as user prompting, error messages and diagnostic circuitry to simplify operation and reduce error.

Standardization Buffers

Buffers—solutions of known pH value—adjust the system to display accurate measurements. Buffers are available as ready-to-use or concentrated solutions, in capsules and as prepackaged salts.

All have the special characteristic of resisting pH change upon dilution or acid/base contamination. For best accuracy, a two-point standardization is performed: first with a buffer value close to the electrode system's zero potential (typically pH 7); and next with an acid or base buffer whose value brackets the expected pH value of the sample. Microprocessor-based meters may permit additional calibrations—up to five points in some models—for increased definition of electrode slope, allowing measurement of samples with widely varying pH values. For best accuracy, all buffers should be at the same temperature as the sample.

The following table lists three buffers established by the National Institute of Standards and Technology, with their pH values at various temperatures.

Temp.	4.01 Buffer 0.05M Potassium Acid Phthalate	6.86 Buffer 1.025M KH_2PO_4 0.025M Na_2HPO_4	9.18 Buffer 0.01M Borax
0°C	4.00pH	6.98pH	9.46pH
10°	4.00	6.92	9.33
20°	4.00	6.88	9.22
25°	4.01	6.86	9.18
30°	4.02	6.85	9.14
40°	4.04	6.84	9.07
50°	4.06	6.83	9.01
60°	4.09	6.84	8.96
70°	4.13	6.85	8.92
80°	4.16	6.86	8.88
90°	4.21	6.88	8.85

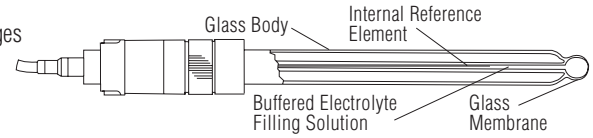
The Electrode System

The electrode system consists of two half cells: a pH indicating electrode, which develops a potential dependent on the pH of a solution; and a reference electrode, which provides a constant potential and completes the electrical circuit.

Using separate pH indicating and reference half cells lets you select each cell without compromise, tailor the system precisely to the sample's nature and achieve the best accuracy. It can mean lower replacement costs, too, since usually only one of a pair is broken.

Nevertheless, the combination electrode—an indicating half cell and a reference half cell joined coaxially—is being used more frequently, for the convenience and compactness it offers. Those which incorporate a temperature probe can provide temperature readout and compensation with ATC-capable meters. Some types of pH, reference and combination electrodes are discussed below and on the following page.

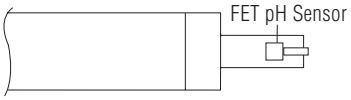
The Electrode Pair



pH Indicating Electrodes

The traditional pH electrode consists of a glass sensing membrane of special electrically-conductive glass, bonded to a nonconductive tube of glass or plastic, called the body; and an internal reference element—usually Ag/AgCl—immersed in a buffered electrolyte of fixed pH value and ionic concentration.

This design assures that constant potentials are developed on the inner surface of the glass membrane, and on the internal reference element. When the electrode is immersed in a solution of pH 7, the sum of these fixed voltages approximately balances the voltage developed on the outer surface of the glass membrane and the separate reference electrode. Thus, in a pH 7 solution, the total potential output of the system is near 0mV. In solutions of more or less than pH 7, the potential on the outer membrane surface changes in proportion to the sample pH. The voltage change is sensed by the meter and displayed as a pH value.



Recent designs have replaced the glass pH membrane with a sensor comprising the gate connection of an ion-sensitive FET (Field Effect Transistor). A pH-related potential is developed across the gate of this semiconductor, which, in turn, controls the current flowing through the transistor. The current output is in essence dependent on the activity of the hydronium ion in the solution being measured. Most such electrodes are designed as combination electrodes.
(See pp. 19 and 22 for AccuFet® model.)

Selecting a pH Indicating Electrode

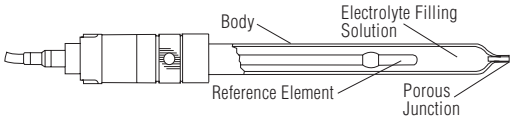
Fisher offers glass pH indicating electrodes with membranes of two types of glass. Both types are usable over the 0 to 14pH range, and feature low error in samples with high sodium content.
(See pp. 19 and 22 for specifications and ordering information.)

FS-5 Universal Glass Membranes have low electrical resistance—less than 100 megohms at 25°C. They're recommended for all routine pH and titration measurements, as well as measurements at low temperatures. Their sodium error is less than 0.01pH (in 0.1N NaOH at 25°C). New models with an extra-thick membrane are available; their rugged bulbs are 40mil in thickness, compared to the standard thickness of 8mil, making them up to five times more durable under rough handling.

Full Range High pH Glass Membranes have somewhat higher electrical resistance plus excellent chemical durability. They're ideal for frequent or long-term measurements in solutions of very high or very low pH value, and feature sodium ion error of less than 0.03pH (in 0.1N NaOH at 25°C).

As an alternative to the glass bulb, Fisher offers AccuFet® combination electrodes with built-in ATC probe and ion-selective field effect transistor sensor. The solid-state sensor precludes breakage, since there's no glass bulb, and the body is of durable epoxy.
(See p. 22 for ordering information.)

Reference Electrodes



The basic requirements of the reference half cell are to *complete the electrical circuit* and to *provide a stable reference potential*. The probe contains a reference element—usually calomel or silver/silver chloride—immersed in an electrolyte solution of fixed ionic concentration. This produces a constant voltage, despite sample composition. The circuit is completed by allowing a small flow of the electrolyte to pass through a junction in the probe tip; or by ionic diffusion in an electrode filled with gelled electrolyte.

Selecting a Reference Electrode

To maintain constant junction potential under specific measurement conditions requires an adequate flow of electrolyte. So the choice of reference electrode is made based on the electrode's flowrate—which depends on its junction type—and on the characteristics of its internal element and electrolyte relative to the sample.

Liquid Junctions cover the majority of applications, with flowrates from 0.5 to 100µL/hr. These junctions perform best with the least junction potential. In most cases, this occurs with a fast-flowing junction; but rapid electrolyte flow can cause significant sample contamination. Hence the need for a variety of junctions to provide a selection of flowrates.

- Sleeve and annular junctions provide flowrates—to 100µL/hr.—for enhanced conductivity and response in solutions of low ionic strength, such as deionized water, and in difficult samples such as slurries, emulsions and suspensions. Sleeve junctions can be removed or slid out of the way to clean or refresh the junction. The reverse sleeve type is designed to prevent loss of the sleeve. Some annular junction models have spring-loaded caps for flow adjustment and easy cleaning.
- Porous ceramic junctions offer moderate flowrates of about 8µL/hr., providing excellent solution contact with minimal need for electrolyte replenishment. They're recommended for the majority of routine pH and titration measurements.
- Cracked bead junctions allow the least amount of electrolyte flow—only 0.5 to 5.0µL/hr.—yet exhibit minimal problems with clogging of the junction.

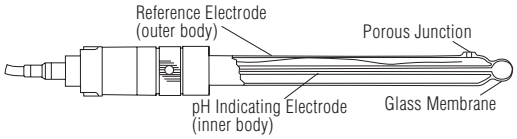
Nonflowing junctions are most often found in polymer body electrodes designed for applications where minimal electrode maintenance is desirable. The electrolyte is usually a gel; contact is by ionic diffusion through a porous junction (rather than by liquid flow). These types are useful for in-plant monitoring, field measurement and classroom use.

Double-junction electrodes permit isolation of the reference element and its electrolyte by enclosing them in an inner electrode body. The flowrate is determined by the second junction, contained in the outer body of the electrode. A choice of outer junctions and electrolytes permits matching of electrode to sample.

Internal elements provide a fixed potential of excellent stability. The choice in most applications is between calomel (Hg/Hg_2Cl_2) and silver/silver chloride (Ag/AgCl) elements. Selection is based primarily on sample temperature, but the effects of the electrolyte solution on the sample should also be considered.

- **Calomel (mercury/mercurous chloride) internals** are recommended for most routine applications. The electrolyte is a saturated solution of potassium chloride (KCl), so they're easy to use and maintain. Typical temperature range is -5° to +80°C.
- **Silver/silver chloride internals** have a wider temperature range of -5° to +100° or 110°C. The electrolyte is 4M KCl, saturated with AgCl to prevent dissolution of the silver chloride portion of the internal element. Though Ag/AgCl internals are usable at higher temperatures, the presence of AgCl in the electrolyte may cause junction clogging with low-conductivity samples, and certain silver-sensitive samples—such as biomedical specimens—can react with the electrolyte, causing additional measuring difficulties. Double-junction Ag/AgCl electrodes are available to prevent sample contamination by heavy metals and reduce junction clogging as well.
(See pp. 22 and 23 for Accumet® reference electrodes.)

The Combination Electrode



The combination electrode contains both pH-sensing and reference half cells, joined in a single body. In most combinations, the pH-sensing cell is enclosed in a tube; its membrane is exposed at the probe tip. The annular space around the inner tube contains the reference element, electrolyte and junction. Advantages of this design are handling convenience and compactness—allowing measurements of smaller samples and in narrow vessels.

They're practical for field measurements too, and come in a wide range of lengths and diameters for use in a variety of containers: test tubes, centrifuge tubes, fraction collectors, cuvets and flasks among others. Even greater compactness is achieved in models which incorporate an Automatic Temperature Compensation probe (ATC) within the combination electrode's body.
(See pp. 21 and 22 for Accumet combination electrodes, including Accu•pHast® variable temperature and AccuFet solid-state electrodes.)

Electrochemistry Theory and Measurements (cont.)

Conductivity Theory and Measurement

Conductivity Theory

Conductance is a value associated with the ability of primarily aqueous solutions to carry an electrical current. Though water itself is a rather poor conductor of electricity, the presence of ions in an aqueous solution increases the solution's conductance considerably. The current is carried by migration of ions dissolved in the water. The solution's conductance is proportional to the concentration of ionic species present, as well as the ions' charge and mobility, and is defined as the reciprocal of the solution's electrical resistance:

Conductance = 1/Resistance

Conductivity measurements, however, generally involve determining the resistance of a small portion of solution between two parallel electrodes when an alternating potential is applied. Conductivity values are related to the conductance of a solution by the physical dimensions—area and length—of the measuring cell, called the cell constant.

Conductance = Conductivity x Cell Constant

Cell Constant = Area/Length

Polarization effects—which would impair the accuracy of the measurements—are avoided by using AC potential, rather than DC; and by coating the electrode's surface area with platinum black. Conductivity measurements provide an easy way to assess the quality of water or of various aqueous solutions.

Conductivity measurements are reported as Siemens/cm, since the value is measured between opposite faces of a cell of known cubic configuration. With aqueous solutions, values are most frequently measured in µSiemens per cm (µS/cm) or milliSiemens per cm (mS/cm).

Some users prefer to use resistivity units to describe their water, particularly where very pure water is involved. Units used to measure resistivity are megohms-cm; they're simply the reciprocals of the conductivity units. The chart below shows the relationship between these two units.

Conductivity µS/cm	Resistivity megohms-cm
0.056	18.0
0.1	10.0
1.0	1.0
2.5	0.4
10.0	0.1

Conductivity Measurement

Conductivity Cells, such as the Accumet models on p. 24, consist of a glass or epoxy body in which platinum or platinized sensing elements are fixed. These sensors contact the solution whose conductivity value is sought. Cell constants—each cell's unique geometric configuration—are determined by measuring the conductivity of a standard of known conductive value, typically an aqueous solution of KCl.

To produce a resistance signal appropriate for a given conductivity meter, it's important to choose a cell with a compatible cell constant. The following table shows optimum conductivity ranges for cells of three different constants.

Cell Constant	Optimum Conductivity Range (µS/cm)
0.1	0.5 to 200
1.0	10 to 2000
10.0	1000 to 200,000

Before use, cells should be conditioned in distilled water for at least 10 minutes, then standardized to determine the cell constant, following instructions supplied with the meter. Conductivity changes considerably with changes in temperature, but the changes are fairly linear, and modern meters provide compensation for accurate standardization.
(See p. 24 for Accumet® conductivity cells.)

Metallic Electrodes

ORP Theory

Oxidation-reduction measurements are used to determine the oxidizing or reducing properties of solutions, to monitor chemical reactions, in quantitative determinations of ions and to detect endpoints in titrations. In chemical oxidation-reduction reactions, electrons are transferred from one species—the reducing agent—to another—the oxidizing agent. Substances vary tremendously in their tendency to act as either oxidizing or reducing agents. Tables of standard oxidation-reduction potentials in the literature are determined relative to the Standard Hydrogen Electrode (SHE) which has a potential of 0.00V at all temperatures (with hydrogen ion activity at 1.00 and the partial pressure of hydrogen gas at 1.00 atmosphere). The standard potential (E^0) of any oxidation-reduction refers to the potential developed vs. the SHE, when all species are at an activity of 1.00 (unit activity). A general equation for a reduction reaction is:

$$Ox + ne^- = Red$$

where n is the number of electrons, Ox is the activity of the oxidized form and Red is the activity of the reduced form.

The ORP can be expressed by the following form of the Nernst Equation:

$$E_H = E^0 \pm 2.3\frac{RT}{nF}\log\left(\frac{Ox}{Red}\right)$$

where E_H is the potential developed between the metallic electrode and the SHE; E^0 is the standard reduction potential; R is the gas constant; T is the temperature in °K; n is the number of electrons involved in the reaction; F is Faraday's constant; Ox is the activity of the oxidized form and Red the activity of the reduced form. Since the SHE is rarely used in practice, the measured potential (E_{meas}) will not be equal to E_H, and E_{meas} must be converted to E_H, using the equation:

$$E_H = E_{meas} + E_{ref}$$

where E_{ref} is the reduction potential of the reference electrode.

ORP Measurement Systems

Oxidation-Reduction Potential (ORP) measurements are displayed in mV, using a metallic indicating electrode and standard reference electrode. In principle, ORP measurements should not require standardization; in practice, it may be necessary to check the system against standards of known potential, as described in ASTM Method D 1498.

The ORP Meter. The meter is usually a pH meter operating in mV mode, and is chosen based on the required resolution: ±5mV, ±1mV, or ±0.1mV. Since automatic temperature compensation does not, in most pH meters, operate in mV mode, and since ORP measurements do vary with temperature, the meter should be adjusted to read 0mV with inputs shorted, for readout in absolute mV. For relative mV readout, the meter is set to some arbitrary value with inputs shorted, or with electrodes immersed in a standard solution.

The Electrode System. This consists of two half cells: a metallic indicating electrode—usually of platinum, gold, silver or mercury—to measure the potential of the reaction, and a reference electrode to provide a constant potential and complete the electrical circuit. The reference, as with pH measurements, should be chosen for the compatibility of its junction type and electrolyte with the sample.
(See p.15 for a discussion of reference electrode selection.
See p. 22 for Accumet metallic electrodes.)

ISE Theory and Measurement

ISE Theory

Ion-Selective Electrodes (ISEs) respond to a particular ion in solution because of the characteristics of the electrode's sensing membrane. Ideally, the ISE develops an electrical potential which is proportional to the concentration of the ion for which the membrane is selective. The most widely-used ISE is the glass-membrane pH electrode; its use is covered on pp.14–15. This section discusses some non-pH types of ISEs.

When an ISE—the indicator electrode—and a reference electrode are placed in a solution and connected to a pH/ion meter, they form a potentiometric cell. At equilibrium, the meter measures the potential differ-

ence between the ISE and the reference electrode. This potential is proportional to the activity of the ion of interest, and the relationship is described by the Nernst Equation:

$$E = E^0 \pm 2.3 \frac{RT}{nF} (\log A)$$

where E is the measured electrode potential; E^0 is the standard potential of the system; R is the gas constant; T is the temperature in °K; F is Faraday's constant; A is the activity of the ion being measured; and n is the number of electrons involved in the reaction.

Activity [A] is not the same as concentration. The activity of an ion is strongly influenced by the total ionic strength of the solution. When ISE measurements are made, a determination in concentration units is usually desired. This is done by adding an Ionic Strength Adjuster (ISA) to samples and standards. When ionic strength is held constant, the Nernst Equation reduces to:

$$E = E^0 \pm 2.3 \frac{RT}{nF} (\log C)$$

where C is the concentration of the ion of interest. This form of the Nernst Equation states that the electrode potential varies directly with the log of the concentration, in a straight-line manner. The slope of the line is equal to the value of:

$$2.3 \frac{RT}{nF}$$

The table below gives theoretical slope values at 25°C:

Species	Slope (mV/decade)
Monovalent cation	+59.16
Monovalent anion	-59.16
Divalent cation	+29.58
Divalent anion	-29.58

The equation is as follows:

$$S = 2.3 \frac{RT}{nF}$$

where S is the electrode's slope. The Nernst Equation thus reduces to:

$$E = E^0 \pm S (\log C)$$

ISE Analysis Methods

Direct Analysis. Although this method is called "direct," some sample preparation is usually needed. Normally, an ionic strength adjuster and/or pH adjuster must be added to samples and standards. Then, standards are used to calibrate a meter, or to construct a calibration curve (by plotting the electrode's output in mV vs. the log of concentration). Sample concentration is then read directly from the meter or calibration curve.

Incremental Methods. These procedures can reduce errors caused by temperature variations, complex matrices and complexation. They're also useful for applications where only occasional samples are analyzed. Incremental methods include: 1) Known Addition; 2) Known Subtraction; 3) Analate Addition; and 4) Analate Subtraction.

With the Known methods, the initial electrode output is measured in the sample solution; then an aliquot of standard is added, and the final electrode output is measured. The concentration of the sample can then be calculated from the change in the electrode's output. Equations for known addition and subtraction follow.

Known Addition:

$$C_s = \frac{C_{std} V_{std}}{(V_s + V_{std}) 10^{\Delta E/S} - V_s}$$

Known Subtraction:

$$C_s = \frac{C_{std} V_{std}}{V_s - (V_s + V_{std}) 10^{\Delta E/S}}$$

where C_s is the concentration of the sample; C_{std} is the concentration of the standard; V_s is the sample volume; V_{std} is the volume of standard; ΔE is the change in electrode output; and S is the electrode's slope.

In the Analate methods, the initial reading is taken with the electrode immersed in the standard; then an aliquot of sample is added, and the final reading taken. Sample concentration is then calculated from the change in electrode output.

Analate Addition:

$$C_s = C_{std} \left[\left(\frac{V_s + V_{std}}{V_s} \right) 10^{\Delta E/S} - \left(\frac{V_{std}}{V_s} \right) \right]$$

Analate Subtraction:

$$C_s = C_{std} \left[\left(\frac{V_{std}}{V_s} \right) - \left(\frac{V_s + V_{std}}{V_s} \right) 10^{\Delta E/S} \right]$$

With modern ISE meters, operating in Concentration, Known Addition or Analate Addition modes, the units of the sample result will be identical to those of the standards used in calibration. However, when operating in either the Known Subtraction or Analate Subtraction modes, the ion of interest in the sample is not identical to the standard species. So it's necessary to enter the standard values in concentration units which take into detailed account the chemical relationship between the standard species and the ion of interest in the sample. The proper choice may be referred to as "stoichiometric equivalency units."

Titrations. Ion-selective electrodes can also be used to detect the endpoint of a titration. The ISE can be selected to monitor either the addition of titrant or the depletion of analate. The electrode potential is plotted vs. the volume of titrant added. The volume corresponding to the equivalence point is determined from the graph, and used to calculate sample concentration.

A number of metallic electrodes are also used in titrations. Dual Platinum Wire and Plate Electrodes, are used with pH meters and titration instruments in deadstop and amperometric titrations; and Silver Billet Electrodes are the choice for silver and halide titrations.
(Accumet® metallic electrode specifications are found on p. 22.)

ISE Measurement Systems

Potentiometric systems for the measurement of a specific ion include an ion meter, calibration standards, and an electrode system consisting of an indicating half cell and a reference half cell.

The Ion Meter. In general, the meter should have a resolution of at least 1mV; a meter with 0.1mV resolution or better is preferred. For direct-read measurements, a meter with concentration mode is necessary; newer microprocessor-based models provide resolution to as many as three significant digits, with excellent accuracy and reproducibility. And for incremental methods, meters now available that will automatically perform the needed calculations, providing readout in ppm, %, mg/mL, mg/L, or most any units you choose. Some current meters have the ability to measure via multiple inputs, permitting simultaneous testing of different samples or measurement of more than one ion in a single sample.

ISE Standardization and Adjustment Solutions. The ion meter/electrode system must be standardized by immersing the electrodes into solutions having a known concentration of the ion of interest. ISE standards are available in a variety of molar, ppm and percent concentrations. Calibration may be done at a single point, usually on less sophisticated meters; or at up to five standardization points, using newer meters.

Additionally, an ionic strength adjuster is required to eliminate interference from other ions and permit readout in units of concentration rather than activity. Since some ISEs have a restricted pH range, a pH adjustment solution may also be necessary. Other special reagents and solutions are available for specific applications.

The Ion-Selective Electrode System. The electrode system consists of: an indicating electrode, which develops a potential dependent on the ionic activity of the sample; and a reference electrode, which provides a constant potential and completes the circuit. The indicating electrode is chosen for its specific response in solutions containing the ion to be measured. The reference electrode is selected based on sample compatibility. Some ISEs are available as combination electrodes, with the indicating half-cell and reference half-cell joined coaxially in a single body.
(See p. 15 for a discussion of reference electrode selection.)
(See pp. 19 and 23 for Accumet ISEs.)

Testing and Standardization of pH Meters and Electrodes

Testing the pH meter:

- For most current meters, attach the BNC shorting cap to the meter's BNC input. *(For older meters, see your instruction manual.)*
- Place the meter in mV mode. Meter's display should now read 0.0mV, ±0.2mV. If the reading is outside of this range, the meter may need to be electronically calibrated.

Testing the electrodes:

- Place the meter in mV mode and measure mV in pH 4 and 7 buffers.
- Determine the net change in millivolts. Example: if the pH 7 buffer reading was -10.0mV, and the pH 4 buffer reading was 159.1mV, the net change would be 169.1mV.
- Divide the result (net change) by 177.5, then multiply by 100 to determine the % of the electrode's slope. *(Example: 169.1/177.5 x 100 = 95.3%.)*
- New electrodes—fresh out of the box—have a slope between 95.0% and 102%. If the slope drops below 92%, clean the electrode.
- If the slope remains below 90.0% or above 102% after cleaning, replace the electrode.

Standardization of electrodes:

- Standardization should be performed at least once a day, and preferably every 2 hours.
- The filling hole should remain open, unless the electrode will be placed in long-term storage.
- At least 2 buffers should be used—one below the expected pH of the sample, and one above the sample pH—to provide linear response in the area of interest.
- Use fresh buffers, stir, then immerse electrode (and an ATC probe) into first buffer. Standardize according to the meter's instructions.
- Rinse the electrode, and place it into second buffer. Once the meter has accepted the second buffer, it will calculate the electrode's % slope.
- New electrodes—fresh out of the box—have a slope between 95.0% and 102%. If the slope drops below 92%, clean the electrode.

Basic pH Electrode Care and Troubleshooting Tips

Liquid-Filled Calomel Electrodes and Ag/AgCl Double-Junction Electrodes:

Start up:

- Remove the end cot and open the fill hole. Add filling solution if necessary.
- Soak at least 2 hours, and preferably overnight, in pH 4 buffer solution.

Storage for less than 1 week:

- Soak the electrode in SE40-1 electrode storage solution, pH 4 or pH 7 buffer solution, with fill hole OPEN.
- Never store electrodes in water; after rinsing, blot them dry—never wipe.

Storage for longer than 1 week:

- Saturate the cotton in the end cot with pH 4 buffer and replace the cot on the glass bulb of the electrode. Close the fill hole and pack the electrode in the original box.

Unblocking the reference junction:

- Soak the electrode tip in 60°C distilled water for 5 to 10 minutes.
- Check electrode for flow by first blotting the reference junction dry with a wiper (e.g., Kimwipe®). Pressurize the electrode for 10 seconds, then blot the reference junction again. If wiper picks up liquid, electrode is flowing.

Liquid-Filled Ag/AgCl Single-Junction Electrodes:

Start up:

- Remove the end cot and open the fill hole. Add filling solution if necessary.
- Soak at least 2 hours, and preferably overnight, in pH 4 buffer solution.

Storage for less than 1 week:

- Soak the electrode in SE40-1 electrode storage solution, pH 4 or pH 7 buffer solution, with fill hole OPEN.
- Never store electrodes in water; after rinsing, blot them dry—never wipe.

Storage for longer than 1 week:

- Saturate the cotton in the end cot with pH 4 buffer and replace the cot on the glass bulb of the electrode. Close the fill hole and pack the electrode in the original box.

Unblocking the reference junction:

- Soak the electrode tip in 60°C saturated potassium chloride for 5 to 10 minutes.
- Check electrode for flow by first blotting the reference junction dry with a wiper (e.g., Kimwipe). Pressurize the electrode for 10 seconds, then blot the reference junction again. If wiper picks up liquid, electrode is flowing.

Gel-Filled Ag/AgCl Single- or Double-Junction Electrodes:

Start up:

- Remove the end cot from the electrode's tip.
- Soak at least 2 hours, and preferably overnight, in pH 4 buffer solution.

Storage for less than 1 week:

- Soak the electrode in SE40-1 electrode storage solution, pH 4 or pH 7 buffer solution.

Storage for longer than 1 week:

- Saturate the cotton in the end cot with pH 4 buffer and replace the cot on the glass bulb of the electrode. Pack the electrode in the original box, and store in upright position.
- Never store electrodes in water; after rinsing, blot them dry—never wipe.

Unblocking the reference junction:

- Soak the electrode tip in 60°C saturated potassium chloride solution for 5 to 10 minutes.

Accumet® Electrodes

for pH, Titrations, ORP, and Ion Selective Electrode Analysis

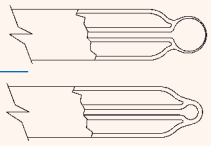
- **Over 30 years of experience in the design, development, and manufacture of electrodes go into each Accumet electrode from Fisher Scientific.**
- **Each electrode is individually tested, serialized to meet GLP requirements, and backed by Fisher's Technical Applications staff.**
- **No matter what the application, we offer an ideal electrode for fast, accurate pH, titration, ORP, conductivity or ISE measurements.**

Accumet® pH Electrodes:

AccuFlow™ *Flushable Junction pH/ATC and pH Electrodes*

Perfect choice for even the most difficult samples! Easy-clean junction, plastic body, choice of Accuo**pH**ast and Ag/AgCl reference types, plus models with ATC element built in for small samples. *(See specifications on p. 21.)*

AccuTupH® *Rugged Bulb pH Electrodes*

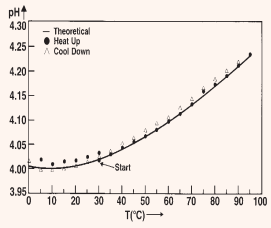


Best choice for durability! Made to be up to 40 times tougher than conventional glass pH electrodes, without sacrificing response time. Available in pH half cell, variable-temperature combination and standard combination models. *(See specifications on p. 21.)*

AccuFet® *Solid-State pH/ATC Electrodes*

Solid state pH/temperature electrodes—the perfect choice for situations where breakable glass electrodes are hazardous. *(See specifications on p. 22.)*

Accu•pHast® *Variable Temperature Electrodes*



Fast, accurate pH measurements! Glass- and epoxy-bodies, patented reference design. Deliver superlative performance even in samples with widely varying temperatures. *(See specifications on p. 21.)*

Accumet *pH, Reference and Combination Electrodes*

Wide choice: glass or plastic, calomel or Ag/AgCl, low maintenance, single- or double- junction, liquid or gel filled, flat surface and microsize electrodes. *(See specifications on pp. 21-23.)*

All Accumet refillable electrodes feature our patented, easy-to-use fill hole technology.

Accumet Conductivity Cells:

Two-cell models (0.1, 1.0 and 10.0cm^{-1} cell constants). Plus new 4 cell models with cell constants of 1.0 and 10.0cm^{-1}. Glass or epoxy bodies. *(See specifications on p. 23.)*

Accumet Metallic Electrodes:

We offer five models, for ORP, silver/halide, Karl Fischer and chlorine measurements. *(See specifications on p. 22.)*

Accumet ISE Electrodes:

Accumet *Polymer Membrane Combination ISEs*

Calcium, Nitrate and Potassium Combinations feature rugged epoxy bodies and refillable reference section. *(See specifications on p. 23.)*

Accumet *Solid-State ISEs*

Cyanide Combination has durable epoxy body, homogeneous membrane. Bromide, Chloride, Copper, Fluoride, Lead and Silver/Sulfide half cells have epoxy bodies, sensing membrane with low microporosity and mirror-like finish to minimize sample retention. Bromide, Chloride, Copper, Fluoride, Lead and Silver/Sulfide Combinations have glass bodies, excellent range and precision. *(See specifications on p. 23.)*

Accumet *Gas-Sensing Combination ISEs*

Ammonia and Carbon Dioxide models feature simple two-piece construction; tough, durable body that's highly resistant to chemicals; permanently-bonded membrane/cap unit. *(See specifications on p. 23.)*

Accumet *Glass-Membrane ISEs*

Sodium Glass-Body Half Cell and Sodium Glass-Body Combination have specially-formulated sodium-responsive glass bulb for direct measurement of active sodium-ion concentration. *(See specifications on p. 23.)*

Accumet *ISE/pH Reference Electrodes*

Single-Junction and Double-Junction types are excellent for ISE determinations, provide premium performance in pH and titration applications, too. *(See specifications on p. 23.)*

Select the Right pH Electrode for Your Application

Application/ Sample Type	Accu•pHast® *Highest Speed and Accuracy*	Accumet® *Ag/AgCl Standard Line*	Accumet *Calomel (Tris Compatible)*	Accumet *Gel-Filled Line*	AccuFet® *Nonglass pH*
*Please **NOTE**: the numbers listed below are partial catalog numbers...13-620-X.*					
General Purpose	-296[B], -281[A]	-285[B], -90[A]	-286[B], -271[A]	-108[B], -104[A]	
Most Sample Types	-298[B], -279[A]	-223[B], -222[A], -110[B/M], -109[B]		-299[B], -283[A]	
	-185[B], -184[A]	-284[B]/-46[P], -3[A]/-46[P]			
	-116[B/M], -117[B]	-294[B]/-46[P], -256[A]/-46[P]			
Biological/	-296[B], -281[A], -116[B/M]	-183[B], -182[A]	-286[B], -271[A]	-299[B], -283[A]	
Pharmaceutical	-297[B], -280[A], -117[B]	-223[B], -222[A], -110[B/M], -109[B]	-293[B], -270[A]		
Proteins, Tris, Enzymes	-185[B], -184[A]	-284[B]/-52[P], -3[A]/-52[P]			
Education/	-298[B], -279[A]	-183[B], -182[A]	-300[B]	-108[B], -104[A]	
Student Use	-113[B/Q], -114[B/M]	-221[B], -220[A]	-288[B], -272[A]	-299[B], -283[A]	
	-185[B], -184[A]	-287[B], -97[A], -98[P/P]			
Emulsions	-116[B/M]	-110[B/M]	-284[B]/-62[P], -3[A]/-62[P]		
Food, Cosmetics, Oils	-117[B]	-109[B]	-284[B]/-61[P], -3[A]/-61[P]		
Flat Surface		-289[B], -83[A]			
Food, Cheese, Agar					
Harsh Environments:					
• **Field or Plant Use**	-298[B], -279[A]	-287[B], -97[A], -98[P/P]	-531[B/M], -AP51[B/W]	-108[B], -104[A]	
	-113[B/Q], -114[B/M]	-530[B/M], -AP50[B/W]	-300[B]	-299[B], -283[A]	
	-116[B/M], -117[B]	-AP1[T], -110[B/M], -109[B]	-288[B], -272[A]		
• **Rugged Use**	-185[B], -184[A]	-183[B], -182[A]		-108[B], -104[A]	
		-181[B], -180[A]		-299[B], -283[A]	
		-221[B], -220[A]		-AP52[B/W], -AP2[T]	
		-187[B]/-53[P], -186[A]/-53[P]	-187[B]/-258[P], -186[A]/-258[P]	-111[B/M], -112[B/Q]	
Large Sample Size	-298[B], -279[A]		-293[B], -270[A]	-290[B], -252[A]	
Tall Flasks or Bottles					
Low Ionic Strength	-296[B], -281[A]	-284[B]/-46[P], -3[A]/-46[P]	-286[B], -271[A]		
Treated Effluent	-116[B/M], -117[B]	-223[B], -222[A], -110[B/M], -109[B]	-284[B]/-61[P], -3[A]/-61[P]		
Nonaqueous	-296[B], -281[A]	-284[B]/-46[P], -3[A]/-46[P]	-286[B], -271[A]		
Solvents, Alcohols		-223[B], -222[A]	-284[B]/-57[P], -3[A]/-57[P]		
Process Monitoring	-185[B], -184[A]	-183[B], -182[A]		-299[B], -283[A]	
		-181[B], -180[A]		-111[B/M], -112[B/Q]	
Pulp & Paper	-185[B], -184[A]	-183[B], -182[A]			
		-223[B], -222[A]		-299[B], -283[A]	
Semisolids					-755[D] (all AR/AB)
Fruit, Meat, Cheese					-758[MD] + -759[B]
					-AP20[T]
Small Sample Size	-297[B], -280[A]	-94[A]	-293[B], -270[A]	-290[B], -252[A]	
Test Tubes, Small Flasks		-291[B], -92[A]			
		-292[B], -93[A]			
Titration	-296[B], -281[A]	-223[B], -222[A]	-286[B], -271[A]		
		-183[B], -182[A]			
		-181[B], -180[A]			
Viscous Samples	-116[B/M]	-110[B/M]	-284[B]/-61[P], -3[A]/-61[P]		
Slurries, Sludges	-117[B]	-109[B]			
Waters:					
• **Acid Rain, Boiler Feed, Distilled, Rain, Well**	-296[B], -281[A]	-223[B], -222[A]	-284[B]/-61[P], -3[A]/-61[P]		
			-286[B], -271[A]		
• **Drinking, Tap**	-296[B], -281[A]	-223[B], -222[A]	-284[B]/-61[P], -3[A]/-61[P]	-108[B], -104[A]	
	-185[B], -184[A]	-284[B]/-46[P], -3[A]/-46[P]	-286[B], -271[A]	-299[B], -283[A]	
• **Sea Water**	-296[B], -281[A]	-223[B], -222[A]			
	-185[B], -184[A]				
• **Wastewater**	-296[B], -281[A]	-284[B]/-46[P], -3[A]/-46[P]		-108[B], -104[A]	
	-185[B], -184[A]	-223[B], -222[A]		-299[B], -283[A]	

[A]With U.S. Standard connector (and Pin connector on combinations). [B]With BNC connector. [B/M] With BNC and Mini-Phone ATC connectors. [B/Q]With BNC and 1/4" Phone ATC connectors. [B/W]Waterproof; BNC and Mini-Phone ATC connectors. [D]With DIN connector. [MD]With Mini-DIN connector. [P]With Pin connector. [P/P]With Dual Pin connectors. [T]With Twist-Lock waterproof connector.

/- Indicating Electrode/Reference Electrode

Refer to the next 3 pages for detailed information on each electrode. NOTE: All Accumet Electrodes are catalog number 13-620-X.

Catalog No.	Description	pH Range	Temp. Range (°C)	Length (mm)	Diameter (mm)	Typical Applications
AccuFlow™ *Flushable Junction, Plastic Body Combination pH Electrodes*						
*With Accu•**pH**ast Reference*						
13-620-117[B/M]	pH/ATC	0–14	0–100	175	12	General Purpose, Tris,
13-620-116[B]	pH	0–14	0–100	175	12	soils, sludges, viscous
With Double Junction Reference						
13-620-110[B/M]	pH/ATC	0–14	0–100	175	12	General Purpose, Tris,
13-620-109[B]	pH	0–14	0–100	175	12	soils, sludges, viscous
Accu•pHast® *Variable Temperature Combination pH Electrodes*						
13-620-281[A]	Standard Glass Body	0–14	-5–100	102	10	General Purpose,
13-620-296[B]						Tris, Water
13-620-280[A]	MicroProbe™ Glass	0–14	-5–100	165	5	Small Samples,
13-620-297[B]	Body					Tris
13-620-279[A]	Extra-Long Epoxy	0–14	-5–100	140	10	Field/Plant Use,
13-620-298[B]	Body					Tris
13-620-113[B/Q]	pH/ATC, Extra-Long	0–14	-5–100	143	10	Field/Plant Use,
	Epoxy Body					Tris
13-620-114[B/M]	pH/ATC, Extra-Long	0–14	-5–100	143	10	Field/Plant Use,
	Epoxy Body					Tris
AccuTupH+® *Variable Temperature Rugged Bulb Combination pH Electrodes*						
13-620-184[A]	Double Junction	0–14	-5–100	102	10	General Purpose,
13-620-185[B]						Tris, Rugged
Accumet® AccuTupH® *Rugged Bulb Glass Body Combination pH Electrodes*						
13-620-180[A]	Single Junction,	0–14	0–100	102	10	General Purpose,
13-620-181[B]	Ag/AgCl Reference					Rugged Use
13-620-182[A]	Double Junction,	0–14	0–100	102	10	General Purpose,
13-620-183[B]	Ag/AgCl Reference					Tris, Water
Accumet *Standard Size Glass Body Combination pH Electrodes*						
13-620-90[A]	Single Junction,	0–14	-5–100	106	10	General Purpose
13-620-285[B]	Ag/AgCl Reference					
13-620-222[A]	Double Junction,	0–14	-5–100	106	10	General Purpose,
13-620-223[B]	Ag/AgCl Reference					Tris, Titration
13-620-271[A]	Single Junction,	0–14	-5–80	106	10	General Purpose,
13-620-286[B]	Calomel Reference					Tris, Water
Accumet MicroProbe™ *Glass Body Combination pH Electrodes*						
13-620-94[A]	Micro tip, Miniature Length,	0–14	-5–110	60	6	Small Samples
	Ag/AgCl Reference					
13-620-92[A]	Micro tip, Standard Length,	0–14	-5–110	100	6	Small Samples,
13-620-291[B]	Ag/AgCl Reference					Test Tubes
13-620-93[A]	Micro tip, Extra Long,	0–14	-5–110	150	6	Small Samples,
13-620-292[B]	Ag/AgCl Reference					Flasks, Tubes
13-620-270[A]	Semimicro, Extra Long,	0–14	-5–80	150	6	Small Samples,
13-620-293[B]	Calomel Reference					Tris, Test Tubes
Accumet *Standard Size Polymer Body Liquid-Filled Combination pH Electrodes*						
13-620-530[B/M]	pH/ATC, Polypropylene	0–14	-5–100	106	10	Field/Plant Use
13-620-AP1[T]	Body, Ag/AgCl Reference					
13-620-531[B/M]	pH/ATC, Polypropylene	0–14	-5–80	106	10	Field/Plant Use,
	Body, Calomel Reference					Tris
13-620-97[A]	Polypropylene Body,	0–14	-5–100	106	10	Field/Plant Use,
13-620-287[B]	Ag/AgCl Reference					Student Use
13-620-300[B]	Polypropylene Body,	0–14	-5–80	106	10	Field/Plant Use,
	Calomel Reference					Tris, Student Use
13-620-220[A]	Polypropylene Body,	0–14	-5–100	106	10	Rugged Use,
13-620-221[B]	Double Junction, Ag/AgCl					Tris, Student Use
13-620-272[A]	Epoxy Body,	0–14	-5–80	106	10	Field/Plant Use,
13-620-288[B]	Calomel Reference					Tris, Student Use
13-620-83[A]	Epoxy Body, Flat Surface,	0–14	-5–100	114	13	Food, Cheese,
13-620-289[B]	Ag/AgCl Reference					Agar, Paper
Accumet *Polymer Body Gel-Filled Combination pH Electrodes*						
13-620-104[A]	Polypropylene Body, gelled	0–14	-5–80	106	10	General Purpose,
13-620-108[B]	Ag/AgCl Reference					Field/Plant Use
13-620-252[A]	Epoxy Body, Pencil-Thin,	0–14	-5–80	178	6	Tall Flasks, Bottles
13-620-290[B]	gelled Ag/AgCl Reference					
13-620-283[A]	Polypropylene Body,	0–14	-5–80	106	10	General Purpose,
13-620-299[B]	Double Junction, Ag/AgCl					Tris, Paper/Pulp
13-620-AP2[T]	pH/ATC, Polypropylene Body,	0–14	-5–80	106	10	Field Use
	Double Junction, Ag/AgCl					
13-620-111[B/M]	pH/ATC, Epoxy Body,	0–14	-5–80	106	10	Field Use
13-620-112[B/Q]	Double Junction, Ag/AgCl					

[A]With U.S. Standard connector (and Pin connector on combinations). [B]With BNC connector. [B/M]With BNC and Mini-Phone ATC connectors. [B/Q]With BNC and 1/4" Phone ATC connectors. [T]With Twist-Lock waterproof connector.

Catalog No.	Description	pH Range	Temp. Range (°C)	Length (mm)	Diameter (mm)	Typical Applications
AccuFet® *Solid-State Combination pH Electrodes*						
13-620-755[D]	pH/ATC Nonglass	0–14	0–100	140	12	Where glass is a concern; for all AR/AB Meters
13-620-758[MD]	pH/ATC Nonglass	0–14	0–100	140	12	Where glass is a concern
13-620-759[B]	Adapter 13-620-758 to BNC	---	---	---	---	
13-620-AP20[T]	pH/ATC Nonglass	0–14	0–100	140	12	Where glass is a concern
Accumet® *pH/ATC Electrodes for AP Series Portable Meters*						
13-620-AP52[B/W]	pH/ATC, Epoxy Body, gelled Ag/AgCl Double Junction	0–14	0–100	102	10	Field Use, AP Series
13-620-AP51[B/W]	pH/ATC, Polypropylene, Calomel, Single Junction	0–14	0–100	102	10	Field Use, AP Series
13-620-AP50[B/W]	pH/ATC, Polypropylene, Ag/AgCl, Single Junction	0–14	0–100	102	10	Field Use, AP Series
Accumet *pH-Indicating Half Cell Electrodes (Require separate reference half cell)*						
13-620-186[A] **13-620-187[B]**	Glass Body, Rugged Bulb pH Half Cell	0–14	0–100	102	10	General Purpose, Rugged Use
13-620-3[A] **13-620-284[B]**	Glass Body, Universal Glass pH Half Cell	0–14	-5–110	102	10	General Purpose, Plant Use
13-620-256[A] **13-620-294[B]**	Epoxy Body pH Half Cell	0–14	-5–110	102	10	General Purpose, Field/Plant Use
13-620-1[A] **13-620-295[B]**	Full Range, High pH Glass, Half Cell	0–14	-5–110	102	10	General Purpose, Field/Plant Use
Accumet *Calomel Reference Half Cell Electrodes (Require separate pH-Indicating half cell)*						
13-620-51[P]	Standard Glass Body, Dri-Pak	0–14	-5–80	105	10	General Purpose, Tris
13-620-52[P]	Standard Glass Body, Prefilled	0–14	-5–80	105	10	General Purpose, Tris
13-620-79[P]	Miniature Glass Body	0–14	-5–80	41	10	Small Samples
13-620-57[P]	Standard Glass Body, Low Flowrate, Cracked Bead Junction	0–14	-5–80	102	10	Nonaqueous
13-620-62[P]	Glass Body, High Flowrate, Sleeve Junction	0–14	-5–80	102	14	Viscous Samples, Slurries, Sludges
13-620-61[P]	Glass Body, High Flowrate, Reverse Sleeve Junction	0–14	-5–80	102	14	Viscous Samples, Slurries, Sludges
13-620-258[P]	Liquid-Filled, Epoxy Body	0–14	-5–80	102	10	Field/Plant Use
13-620-259[P]	Gel-Filled, Epoxy Body	0–14	-5–80	102	10	Field/Plant Use
Accumet *Ag/AgCl Reference Half Cell Electrodes (Require separate pH-Indicating half cell)*						
13-620-53[P]	Glass Body, Single Junction	0–14	-5–110	105	10	General Purpose
13-620-273[P]	Glass Body, Double Junction	0–14	-5–110	102	10	General Purpose, Tris
13-620-46[P]	Single Annular Junction, Epoxy Body, Ag/AgCl	0–14	0–100	108	13	Calcium cyanide, divalent cation, fluoride, sodium, redox, pH
13-620-47[P]	Double Junction (Annular/Ceramic), Epoxy Body, Ag/AgCl inner, outer chamber empty for use with sample-compatible electrolyte	0–14	0–100	108	13	Bromide, chloride, copper, iodide, lead, nitrate, silver/sulfide; redox and pH applications requiring compatible electrolyte
13-620-45[P]	Glass Body, Side Arm for Remote Filling	0–14	-5–110	105	10	General Purpose
Accumet *Metallic Electrodes*						
13-620-115[P]	Platinum Half Cell, Glass Body	---	-5–100	140	10	ORP measurements, redox titrations
13-620-122[P]	Silver Billet Half Cell, Glass Body	---	-5–100	140	10	Silver and halide titrations
13-620-149[P/P]	Dual Platinum Plate Combination	---	10–80	114	13	Chlorine titrations with CI Titrimeter®
13-620-123[P/P]	Dual Platinum Pin Combination	---	-5–100	140	13	KF, dead-stop titrations, sulfur analyses
13-620-82[A] **13-620-81[B]**	Platinum Ag/AgCl Combination	---	-5–100	140	10	Environmental ORP measurements

[A] With U.S. Standard connector (and Pin connector on combinations). [B] With BNC connector. [B/W] Waterproof; BNC and Mini-Phone ATC connectors. [D] With DIN connector. [MD] With Mini-DIN connector. [P] With Pin connector. [P/P] With Dual Pin connectors. [T] With Twist-Lock waterproof connector.

Catalog No.	Description	Range M/(ppm)	Interferences	pH/Temp./ Range	L x Dia. (mm)	Typical Applications
Accumet® *Polymer Membrane Ion Selective Electrodes*						
13-620-537[A] **13-620-536[B]**	Calcium Combination, Epoxy Body	10^{-6} to 10^{-2} 0.04 to 400	Mg^{++}, Zn^{++}, Ba^{++}, K^{+}, Na^{++}, Ni^{++}, Cu^{++}, Fe^{++}, Sr^{++}, H^{++}, Hg^{++}, Pb^{++}	3 to 10pH 0° to 40°C	102 x 13	Foods, beverages, soil, pharmaceuticals, explosives, fertilizers, plants, EDTA titration endpoint
13-620-535[A] **13-620-534[B]**	Nitrate Combination, Epoxy Body	7 x 10^{-6} to 1 0.5 to 62,000	Cl^{-}, NO_2^{-}, Br^{-}, CN^{-}, ClO_3^{-}, I^{-}, ClO_4^{-}	2.5 to 11pH 0° to 40°C	102 x 13	Pollution testing, foods, pharmaceuticals, explosives, fertilizers, plants, meats, pickling baths
13-620-533[A] **13-620-532[B]**	Potassium Combination, Epoxy Body	10^{-6} to 1 0.04 to 39,000	Cs^{+}, NH_4^{+}, Tl^{+}, H^{+}, Ag^{+}, $+Tris^{+}$, Li^{+}, Na^{+}	2.5 to 11pH 0° to 40°C	102 x 13	Body fluids, soils, sewage, fertilizers, foods, beverages
Accumet *Solid-State Ion Selective Electrodes*						
13-620-520[A] **13-620-521[B]**	Bromide Half Cell, Epoxy Body	5 x 10^{-6} to 1 0.4 to 79,000	I^{-}, CN^{-}, $S^{=}$	0 to 14pH 0° to 100°C	102 x 13	Biological fluids, soil, plants, water, effluents, foods. Method ASTM approved
13-620-524[A] **13-620-525[B]**	Bromide Combination, Glass Body	5 x 10^{-6} to 1 0.4 to 79,000	$S^{=}$, I^{-}, CN^{-}, high levels of Cl^{-}, NH_3	2 to 14pH 0°to 80°C	108 x 13	
13-620-518[A] **13-620-519[B]**	Chloride Half Cell, Epoxy Body	5 x 10^{-5} to 1 1.8 to 35,500	Br^{-}, I^{-}, CN^{-}, $S^{=}$, OH^{-}	0 to 14pH 0° to 100°C	102 x 13	Water/wastewater, soil, dairy, tomato/vegetable products, meats. Method ASTM/AOAC approved
13-620-526[A] **13-620-527[B]**	Chloride Combination, Glass Body	5 x 10^{-5} to 1 1.8 to 35,500	$S^{=}$, I^{-}, CN^{-}, OH^{-}, Br^{-}	2 to 12pH 0° to 80°C	108 x 13	
13-620-540[A] **13-620-541[B]**	Cupric Half Cell, Epoxy Body	10^{-8} to 10^{-1} 6.4x 10^{-4} to 6350	Ag^{+}, Hg^{++}, Cl^{-}, Br^{-}, Fe^{+},Cd^{++}	2 to 12pH 0° to 80°C	102 x 13	Plating baths, natural water, silicon
13-620-546[A] **13-620-547[B]**	Cupric Combination, Glass Body	10^{-8} to 10^{-1} 6.4x 10^{-4} to 6350	Ag^{+}, Hg^{++}, Cl^{-}, Br^{-}, Fe^{+},Cd^{++}	2 to 12pH 0° to 80°C	108 x 13	
13-620-539[A] **13-620-538[B]**	Cyanide Combination, Epoxy Body	5 x 10^{-6} to 10^{-2} 0.1 to 260	Cl^{-}, Br^{-}, I^{-}, $S^{=}$ absent	11 to 13pH 0° to 80°C	102 x 13	Petrochemical, plating water, wastes
13-620-522[A] **13-620-523[B]**	Fluoride Half Cell, Epoxy Body	Sat. to 10^{-6} Sat. to 0.02	OH^{-}	5 to 9pH 0° to 80°C	102 x 13	Water/wastewater, stack gases, explosives, etching baths, bioresearch, beverages, detergents.
13-620-528[A] **13-620-529[B]**	Fluoride Combination, Glass Body	Sat. to 10^{-6} Sat. to 0.02	OH^{-}	5 to 8pH 0° to 80°C	108 x 13	Method ASTM/EPA approved
13-620-542[A] **13-620-543[B]**	Lead Half Cell, Epoxy Body	10^{-6} to 10^{-1} 0.2 to 20,700	Ag^{+}, Hg^{++}, Cu^{++}, Cd^{++}, Fe^{++}	3 to 8pH 0° to 80°C	102 x 13	Organic compounds, biological samples
13-620-548[A] **13-620-549[B]**	Lead Combination, Glass Body	10^{-6} to 10^{-1} 0.2 to 20,700	Ag^{+}, Hg^{++}, Cu^{++}, Cd^{++}, Fe^{++}	3 to 8pH 0° to 80°C	108 x 13	water/wastewater
13-620-544[A] **13-620-545[B]**	Silver/Sulfide Half Cell, Epoxy Body	10^{-7} to 1.0 (Ag^{+}/$S^{=}$) 0.01 to 107,900 (Ag^{+})	Hg^{++}, Hg^{++}	2 to 12pH 0° to 80°C	102 x 13	Water, pulping liquors
13-620-550[A] **13-620-551[B]**	Silver/Sulfide Combination, Glass Body	0.003 to 32,100 ($S^{=}$)		2 to 12pH 0° to 80°C	108 x 13	
Accumet *Gas-Sensing Ion Selective Electrodes*						
13-620-504[A] **13-620-505[B]**	Ammonia Combination, Epoxy Body	5 x 10^{-7} to 10^{-1} 0.009 to 1700	Volatile amines, metal cations that complex ammonia	13pH 0° to 50°C	108 x 18	Sewage effluent, boiler water, industrial waste, stack gases, food, fertilizers. Method ASTM/EPA approved
13-620-506[A] **13-620-507[B]**	Carbon Dioxide Combination, Epoxy Body	10^{-5} to 3 x 10^{-2} 0.440 to 1320	Volatile organic acids	4.5pH 0° to 50°C	108 x 18	Measures carbon dioxide, carbonate, bicarbonate in beverages, wines, ground/sea water
Accumet *Glass-Membrane Ion Selective Electrodes*						
13-620-500[A] **13-620-501[B]**	Sodium Half Cell, Glass Body	10^{-6} to 10^{0} 0.023 to 23,000	Ag^{+}, Li^{+}, K^{+}, NH_4^{+}	0 to 14pH 0° to 80°C	102 x 13	Meats, fish, dairy products, fruit juices, brewing water, ground water, sea water, soils, bodily fluids
13-620-502[A] **13-620-503[B]**	Sodium Combination, Epoxy Body	10^{-6} to 10^{0} 0.023 to 23,000	Ag^{+}, Li^{+}, K^{+}, NH_4^{+}	0 to 14pH 0° to 60°C	114 x 13	

[A]With U.S. Standard connector (and Pin connector on combinations). [B]With BNC connector.

Catalog No.	Description	pH Range	Temp. Range (°C)	Length (mm)	Diameter (mm)	Typical Applications
Accumet® Annular Junction Reference Half Cells *For ISEs*						
13-620-46[P]	Single Annular Junction, Epoxy Body, Ag/AgCl	0–14	0–100	108	13	Calcium, cyanide, divalent cation, fluoride, sodium, redox, pH
13-620-47[P]	Double Junction (Annular/ Ceramic), Epoxy Body, Ag/AgCl inner, outer chamber empty for use with sample-compatible electrolyte	0–14	0–100	108	13	Bromide, chloride, copper, iodide, lead, nitrate, silver/sulfide; redox and pH applications requiring compatible electrolyte

Cell Constant	2-Cell Models Cat. No.		4-Cell Models Cat. No.	
	Glass Body	Epoxy Body	Glass Body	Epoxy Body
Accumet® Immersion Type Conductivity Cells *For Accumet AB30, AR20, and AR50 Meters*				
0.1cm^{-1}	**13-620-156**[P/P]	**13-620-161**[P/P]	---	---
1.0cm^{-1}	**13-620-155**[P/P]	**13-620-160**[P/P]	**13-620-163**[D/M]	**13-620-165**[D/M]
10.0cm^{-1}	**13-620-157**[P/P]	**13-620-162**[P/P]	**13-620-164**[D/M]	**13-620-166**[D/M]

[D/M]With DIN and Mini-ATC connector. [P]With Pin connector. [P/P]With Dual Pin connectors.

pH	Color	Ingredients	Size	Catalog No.
pH Buffers				
4.00	Red	Potassium Biphthalate	500mL	**SB101-500**
7.00	Yellow	Potassium Phosphate Monobasic & Sodium Hydroxide	500mL	**SB107-500**
10.00	Blue	Potassium Carbonate, Potassium Borate & Potassium Hydroxide	500mL	**SB115-500**
4, 7, 10	---	Fisher Buffer-Pac: 500mL ea. of color-coded pH 4, 7, and 10 buffers	3x500mL	**SB105**
4.00	Red	Individual Tear-open pH Packets	20/box	**SB4**
7.00	Yellow	Individual Tear-open pH Packets	20/box	**SB7**
10.00	Blue	Individual Tear-open pH Packets	20/box	**SB10**

Description	Size	Catalog No.
Electrode Care and Storage		
Electrode Rinse Solution in Individual Tear-open Packets; color-coded Gray	20/box	**SB15**
Electrode Storage Solution	1L	**SE40-1**
Electrode Storage Bottle	---	**13-620-499**

Description	Size	Catalog No.
Electrode Filling Solutions		
Saturated KCl. For all calomel single-junction electrodes; for outer chamber of all Ag/AgCl double-junction, Accu•**pH**ast®, AccuTu**pH**® and AccuTu**pH**+® electrodes.	500mL	**SP138-500**
4M KCl Saturated with AgCl. For all Ag/AgCl single-junction electrodes; for inner chamber of all double-junction electrodes except Accu•**pH**ast and AccuTu**pH** electrodes.	500mL	**SP135-500**

ISE	Solution	Size(mL)	Catalog No.
Standards and Solutions for Accumet ISEs			
Ammonia	0.1M NH_4Cl	500	**13-620-800**
	1000ppm as NH_3	500	**13-620-801**
	pH/ISA; 10M NaOH	500	**13-620-802**
	Filling solution	500	**13-620-803**
Bromide	0.1M NaBr	500	**13-620-821**
	1000ppm Br^-	500	**13-620-822**
	ISA; 5M $NaNO_3$	500	**13-620-823**
Calcium	0.1M $CaCl_2$	475	**13-620-811**
	100ppm Ca^{++}	475	**13-620-862**
	ISA; 4M KCl	475	**13-620-851**
Carbon Dioxide	0.1M $NaHCO_3$	500	**13-620-804**
	ISA	500	**13-620-805**
	Filling solution	500	**13-620-806**
Chloride	0.1M NaCl	500	**13-620-818**
	1000ppm Cl^-	500	**13-620-819**
	ISA; 5M $NaNO_3$	500	**13-620-820**
Cyanide	ISA; 10M NaOH	500	**13-620-802**
Fluoride	0.1M NaF	500	**13-620-824**
	1000ppm F^-	500	**13-620-825**
	TISAB	500	**13-620-831**
	TISAB II	500	**13-620-835**
Nitrate	0.1M $NaNO_3$	475	**13-620-888**
	1000ppm N	475	**13-620-910**
	100ppm N	475	**13-620-924**
	ISA; 2M $(NH_4)_2SO_4$	475	**13-620-850**
Potassium	0.1M KCl	475	**13-620-917**
	ISA; 5M NaCl	475	**13-620-927**
Sodium	10% NaCl	500	**13-620-826**
	100ppm as Na^+	500	**13-620-827**
	1000ppm as Na^+	500	**13-620-828**
	ISA	500	**13-620-832**

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